

FINNISH APL ASSOCIATION

# FINNAPL IDIOM LIBRARY

SECOND EDITION

Jul. 13, 1982



Helsinki 1982

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## FOREWORD OF FIRST EDITION

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The publication of this APL idiom collection was initiated by the FinnAPL Working Group of Programming Techniques in spring 1981, when good ways of teaching and promoting efficient use of APL were being discussed. It is a widely known fact that some idiom containing booklets and APL workspaces exist. However, the working group discovered several deficiencies in the usefulness of these sources: difficult and slow access, the relatively small amount of idioms and the lack of appropriate search methods. These arguments led to the decision of building a versatile, easy-to-use idiom library, from which any APL user can find practical tools for daily work. The goal of this publication is to promote good and efficient APL usage by means of APL idioms, and facilitate and speed up APL programming.

The first and most important source of idioms has been the Working Group itself - the experience and everybody's own idiom reservoirs. The members of the group are:

Arto Juvonen	TMT-Team
Seppo Kaltio	TMT-Team
Timo Kunnas	Helsinki University of Technology
Timo Laurmaa	Bank of Helsinki
Hannu Lehto	Datema
Heimo Penttinen	Finnish Broadcasting Company
Tauno Ylinen	Ministry of Finance

Also the following publications were very useful:

- A.J. Perlis, S. Rugaber:  
Programming with Idioms in APL,  
APL Quote Quad, vol. 9, no. 4, 1979
- K.E. Iverson:  
Notation as a Tool of Thought  
Communications of the ACM, vol. 23, no. 8,  
August 1980
- O.I. Franksen:  
Computing - An Economy of Thought  
NordDATA81, Copenhagen 1981
- R.P. Polivka, S. Pakin:  
APL: The Language and Its Usage  
Prentice-Hall, 1975
- R.A. Smith  
A Programming Technique for Non-rectangular  
Data, APL79 Conference Proceedings, ACM.

The Finnish APL Association is pleased to receive any comments and new idioms in order to increase the versatility and quality of this idiom library.

#### FOREWORD OF SECOND EDITION

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The second edition of the FinnAPL Idiom Library differs from the first one in several aspects: the number of idioms has been increased from 452 to 631, most of the idioms have been tested with a computer, many errors have been corrected, some explanations have been made easier to understand, and a function-based index has been included. The publication is also introduced in a more compact version (FinnAPL Pocket Idiom Library).

The working group for this edition has been:

Akif Ali	Helsinki University of Technology
Timo Kunnas	Helsinki University of Technology
Timo Laurmaa	Bank of Helsinki

FinnAPL wishes to thank for the numerous contributions by APL users from several countries, and is still pleased to receive comments and new idioms to help in developing future editions of the library.

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## THE USE OF IDIOMS IN APL

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Arto Juvonen  
TMT-Team

### 1. INTRODUCTION

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Idiom is a speech form that is peculiar within the usage of a given language. In APL, an idiom is a meaningful primitive structure constructed from primitive functions. Idiom is characterized by ease of recognition, frequency of occurrence and flexibility in use. Due to APL's conciseness and functional nature the language contains a large number of useful idioms, whose familiarity makes the programming effort more efficient and unravels programs made by others.

An idiom is an APL primitive construct like the APL primitive and derived functions because of its presence in the language. However, an idiom has a special connotation, that cannot be directly derived from its constituents. Once the idiom is learned, the meaning can be perceived from the program line without analyzing the structure function by function. Let us take as an example the 'if'-idiom `[1` in a conditional branch statement. Due to the expression `→LINE[COND` the program branches to line LINE, if COND (1 or 0) is true. Otherwise execution continues at the next line. The expression might be difficult to decipher, if the idiom is not familiar. After learning the behavior of the idiom the use and understanding of it is trivial.

One of the main characteristics of an idiom is its conciseness. It is easy to remember and recognize and quick to type. Because of this it is not necessary to define an idiom as a function, although this is quite common. Idioms are often more useful as part of another expression. By writing the idiom straight to the function line the naming problem can be avoided. A person acquainted with the idiom does not have to know in which workspace and with which name the expression is saved, and does not have to copy the function into the workspace. Also the problem of having a different object of the same name in the workspace can be avoided. Moreover, the reader of the program does not have to recognize the name. It is also useful to use idiomatic expressions in the library subroutines instead of the equivalent

defined functions to avoid chained calls and thus group definitions or copying of defined library functions one by one during the first application programming test run.

The difference between an idiom and a defined function can easily be seen. An important difference is their length. Idioms are almost always expressed naturally in one line. A defined function may contain more complicated, e.g. iterative structures. If an idiom is embedded in a defined function, it is useful to write it in a general form to allow wider use. Thus in a defined function the idiom is hidden in the jungle of shape and reshape functions that guarantee the compatibility of the arguments. If the idiom is written as part of the function line, the simplest form according to the current arguments can be used. There are also idioms that cannot be written as a function because of the great number of arguments or some other special feature. Such idioms are e.g. templates, that can be used to create new idioms.

## 2. THE USE OF IDIOMS IN WRITING AND READING PROGRAMS

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No language contains a perfect set of functions for every need encountered in solving problems. APL idioms can often be used as APL primitive functions. They make the language more expressive and bring the language nearer to the human thought structures. Idioms act as an intermediate language in man-machine communication. Thus, mastering a group of basic idioms is necessary for efficient APL programming allowing the lines to be written from left to right and not a function at a time from right to left.

Idioms act also as a means of conveying thoughts between the program writer and the reader. Understanding a program is a discontinuous process. The meaning of a line is first unclear. After initial research the reader can make a hypothesis of the meaning. Additional studying verifies the model. Insight is more easily attained if the program writer and reader share a large number of idioms. Not knowing the idiom written by someone else interrupts understanding of the program flow. The reader can study the result of functions applied to sample arrays element by element, but making a hypothesis of the meaning of the expression may be very difficult.

Thus both in writing and reading programs

mastering a large set of idioms is an invaluable tool. Idioms should be learned early while learning other language fundamentals, as this helps to organize the students understanding of the numerous possibilities of the primitive functions and their combinations. Idioms are best learned by encountering them in different environments and by using them. New idioms can be found by using one-line solutions, as this helps avoiding splitting of data and thought.

### 3. EXAMPLES OF IDIOMS

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Idioms can be classified for example in the following manner:

1. Structural
2. Sorting
3. Searching
4. Tests
5. Forming boolean vectors
6. Text processing
7. Numerical
8. Object generators
9. Subvector processing
10. Templates

Changing the structure of an array is common because of the compatibility requirements of functions. A typical example is forming a vector into a one line matrix  $V \leftarrow (1, \rho V) \rho V$  or a 'column vector'  $V \leftarrow \Omega(1, \rho V) \rho V$ . A numeric vector can be reshaped also with the idiom  $V \leftarrow V * . +, 0$ . Often operating with higher dimensional arrays may be cumbersome. E.g. multiplying an array A of shape k,m,n with array B of shape k,m,l,n so that the elements along the second axis of A are also used for multiplying the elements along the third axis of B necessitates forming a new axis in A after the second axis. The new axis is first shaped to contain a dimension of length one. The dimension is replicated l times by indexing:

$S \leftarrow (1, \rho A)[2 \ 3 \ 1 \ 4] \rho A$  and  $S \leftarrow S[; ; (\rho B)[3] \rho 1; ]$ . An array is restructured often by the transpose function  $T \Omega A$ . The element  $T[I]$  specifies, where the i:th axis of the argument array will be located in the resulting array. Thus forming a new axis after the i:th axis and replicating it n times can be generally stated with the idiom  $(\Phi \Phi(I+1), 1 \rho \rho A) \Omega(N, \rho A) \rho A$ .

Sorting arrays is based on the grade primitive function  $\Phi$ . The task of idioms is to create suitable numeric arguments for the grade function.

For example a word list can be sorted with the idiom  $I \leftarrow \uparrow(A) \downarrow \uparrow(A) \downarrow M$ , where  $A$  contains the alphabet used and  $M$  the words to be sorted. By using this idiom a sorting of 8 to 10 columns can be performed at a time. Sorting a wider matrix or taking other factors into consideration requires sorting to be started with the least significant sorting factor and indexing the next factor with the resulting grade vector. E.g. forming the grade vector  $I$  by using the first two columns of a numeric matrix  $M$  would be performed by using first the second column  $I \leftarrow \uparrow M[;2]$  and then the first one  $I \leftarrow I[\uparrow M[I;1]]$ .

Often we have to sort numeric codes in vector  $A$  to the corresponding sequence  $S$  e.g. for summing. The required grade vector can be formed with the idiom  $I \leftarrow \uparrow S \downarrow A$ .  $A[I]$  can be used to get the lengths of the subvectors to be summed.

Searching is often based on location function  $(\downarrow)$  or compression of indices  $L/\downarrow L$ . The location function can be used e.g. to locate the index of the first positive element in vector  $V$ :  $(V>0)\downarrow 1$  or the index of the first occurrence of vector  $A$  in matrix  $M$ :  $(M \wedge, = A)\downarrow 1$ .

Test idioms are very frequent. Good examples are the test of numericity of an array  $A$ :  $0 \in 0 \downarrow 0 \uparrow A$ , and the test of emptiness:  $0 \in \uparrow A$ , and the test of equalness of all elements in vector  $A$ :  $\wedge / A = 1 \uparrow A$ .

Forming a modification of a logical vector is often fundamental when using the APL way of solving problems. E.g. the following transformations can be performed to a logical vector (array):

Turn on all 0's after the first 1

```
L ←      0 0 1 0 1 0 1
v\L      0 0 1 1 1 1 1
```

Leave on the 1's preceding the first 0

```
L ←      1 1 1 0 1 0 1
^L      1 1 1 0 0 0 0
```

Leave on only the first 1

```
L ←      0 0 1 0 1 1 1
<L      0 0 1 0 0 0 0
```

Create a vector of running even parity

```
L ←      1 0 0 1 1 0 1
≠L      1 1 1 0 1 1 0
```

Leave on the first 1 on each group of 1's  
 $L \leftarrow$  0 1 1 0 1 1 1  
 $L \leftarrow \neg 1 \downarrow 0, L$  0 1 0 0 1 0 0  
 Generally  $L \leftarrow ((\neg p p L) \uparrow \neg 1) \downarrow 0, L$

Leave on the first group of 1's  
 $L \leftarrow$  0 1 1 0 1 1 0  
 $L \wedge \wedge \setminus L = v \setminus L$  0 1 1 0 0 0 0

Leave on the groups of 1 in B indicated by the corresponding 1 in vector L  
 $L \leftarrow$  0 1 0 0 0 0 1 0 1  
 $B \leftarrow$  1 1 1 0 1 1 0 1 1  
 $B \wedge A \in (L \wedge B) / A \leftarrow \setminus B \neg 1 \downarrow 0, B$  1 1 1 0 0 0 0 1 1

Text processing often aims at finding a character or a character string satisfying given conditions. Because APL primitive functions use a character as an element, the text and word processing area contains many idioms to perform higher level operations. Some examples are deletion of blanks from a character vector V:  $(V \neq ' ') / V$ , deleting leading blanks  $(v \setminus V \neq ' ') / V$  and trailing blanks:  $(\neg 1 \uparrow (V \neq ' ') / \setminus p V) / V$ . Replacing each element A in vector V with B:  $V[(V=A) / \setminus p V] \leftarrow B$  is simple, and the idiom  $V[L / \setminus p L] \leftarrow B[(L \leftarrow I \leq p A) / I \leftarrow A \setminus V]$  can be used, if A and B are vectors. The occurrences of vector A in vector V can be located with the idiom  $I \leftarrow (V[I \leftarrow \neg 1 + \setminus p A] \wedge \setminus A) / I \leftarrow (I = 1 \uparrow A) / \setminus p I \leftarrow (1 - p A) \downarrow V$ . In it the possible starting locations are found by the initial letter and the length of A. The substrings of V starting from these indices are compared with A.

Vectors are often the most convenient way to handle data because of flexible selection and indexing. A vector is often divided into variable length parts (subvectors) that must be operated on analogously. In the following examples a boolean vector P indicates the partitioning of the argument vector.

$P \leftarrow$  1 0 0 0 1 0 1  
 $A \leftarrow$  1 2 3 4 5 6 7 and  $L \leftarrow$  1 1 0 1 0 0 1

The lengths of the parts  
 $Z \leftarrow Z \neg 1 \downarrow 0, Z \leftarrow (1 \Phi P) / \setminus p P$  4 2 1

The sum of the elements of parts in A  
 $Z \leftarrow Z \neg 1 \downarrow 0, Z \leftarrow (1 \Phi P) / + \setminus A$  10 11 7

The or-reduction of the parts in vector L  
 $Z \leftarrow (P / L) \geq Z / 1 \Phi Z \leftarrow (P \vee L) / P$  1 0 1

A template is a model that can be used to create useful structures. In the following templates  $\alpha$  stands for a suitable function or another idiom. Template  $(\rho A)\rho\alpha, A$  means raveling array  $A$ , operating on it and reshaping it back to the original shape. By using this template and a suitable idiom we can e.g. change the elements  $A$  in array  $S$  to  $B$ :  $V[(V=A)/(\rho V\leftarrow S)]\leftarrow B$  and  $S\leftarrow(\rho S)\rho V$ .

Using numerical calculation instead of conditional branching is often useful. E.g. idiom  $(X \times B) + Y \times \sim B$  can be used to select an element from  $X$  if the corresponding element in  $B$  is true, otherwise from  $Y$ . The idiom  $X \times 1 - 1[B+1]$  can be used to negate the elements of  $X$  indicated by  $B$ .

The template  $A \times B \circ \alpha C$  encourages to use outer product to compute all needed combinations and to select the needed ones with the diagonal transpose. For example adding the vector  $X$  to the columns of matrix  $M$  can be performed with the idiom  $1 \ 1 \ 2 \times X \circ \cdot + M$ .

## HOW TO USE THIS IDIOM LIBRARY

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Timo Laurmaa  
Bank of Helsinki

### 1. THE PARTS OF THE IDIOM LIBRARY

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#### 1.1 Idiom List

The library is based on an idiom list containing 631 APL idioms. Every idiom consists of an APL expression, a brief verbal description, the description of arguments and parameters, and an index number. The list is sorted in a 'functionally alphabetical' order; therefore two very similar idioms will not be far from each other. The functionally alphabetical order is based on the order of functions listed in the Table of Functions so that e.g. expressions containing  $\uparrow$  are found in the beginning of the list and so on.

The argument description states the requirements set to the variables in the expression (arguments or parameters). The most common requirements include information of the rank or shape of the array as well as the type, according to the following rules:

- Naming convention of data objects:
  - X,Y arguments
  - G,H parameters
  - A,B intermediate results etc.
- Data type expressions (in argument descriptions):
  - C = character
  - B = logical (boolean)
  - I = integer
  - D = any numeric data type
  - A = any data type, no limitations
- Representation of the ranks of arrays:
  - 0 = scalar
  - 1 = vector
  - 2 = matrix
  - = (empty) no limitations; the shape is mentioned separately, if necessary
- Examples
  - X $\leftarrow$ D2 argument X is a numeric matrix
  - G $\leftarrow$ I0 parameter G is an integer scalar

## 1.2 Permuted index

The bulk of this idiom library consists of an alphabetical index sorted according to a so-called permuted index (keyword in context) method. This method is used in order to facilitate finding appropriate idioms with the assistance of typical keywords. A verbal description with  $n$  words will usually occur in  $n$  places in the index, at the place of each word of the description. This provides an easy way to find a suitable idiom even if its description is not completely known. The index contains a reference to the index numbers in the idiom list. If a description corresponds to two idioms with numbers clearly unequal, it is likely that the desired result can be achieved with two highly different solutions (nearly equal numbers would indicate similarly built expressions).

## 1.3 Synonym List

Same results can be achieved in several different ways in APL. This list is a collection of certain idioms from the idiom list that perform (at least approximately) similar operations. (They may differ from each other for instance by requirements set for their arguments.) The synonym list gives a good insight of how to produce similar results in many different ways in APL. Studying these differences will certainly help widening the understanding of APL idioms and expressions.

## 2. LIMITATIONS OF THE IDIOM LIBRARY

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APL idiom library has been designed for the most common programming circumstances. Consequently, some idioms will not work as desired in every special situations. The idioms will generally work with at least the default values of a VS APL empty workspace, which usually apply also in application workspaces. Possible circumstances for unexpected behaviour of certain idioms might be for instance

- DPP=4      Printing precision is small
- DCT=0.1    Comparison tolerance is high

The index origin `ⓘ` deserves special consideration. As the default value is one, every idiom (unless the description states differently) will work if `ⓘ = 1`. Several idioms include `ⓘ` in the APL expression, which means that the idiom works with both possible `ⓘ` values. Exception

cases (works only if `DIO = 0`) are reported separately in the verbal description. The great majority of the idioms will work in the expected way, independent of parameter values.

This publication intends to present only efficient idioms that promote good APL programming style. It is, however, sometimes difficult to decide if an APL expression will be efficient in every situation. Therefore, especially in handling very large data objects there is a danger that huge amounts of cpu time will be spent or that a `WS FULL` occurs unexpectedly. If the idiom is good in principle ( `(X\X)=1pX` is a typical example), but in some conditions may turn out to be inefficient, this is mentioned in the verbal description. Avoiding `WS FULL` problem is possible for instance with the thumb rule stating that the outer product `*` may easily cause a `WS FULL` if large data objects are being handled.

Some idioms include numeric or character constants which make the idioms more recognizable but seem to reduce their generality. For instance, the idiom `DIVIDING A 400x12 CHARACTER MATRIX INTO ONE PAGE` contains the constants 400 and 12, which clearly have to be modified according to the column width and page length.

Certain idioms contain the delta function  $\Delta$  needed when chaining expressions. If these idioms are used, the workspace should contain this function defined in the following way:

```
      ∇Z←A Δ B
[1]   Z←A
      ∇
```

This function causes the rightmost expression to be processed first. The leftmost expression will then be executed independently of the result of the previous one.

### 3. EXAMPLES OF THE USE OF THE IDIOM LIBRARY

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#### 3.1 Finding an idiom to perform a desired task

If we want to use the idiom library to find an expression that underlines a text vector, we can examine words `UNDERLINE`, `TEXT` and `VECTOR` in the index. If the desired idiom belongs to the library, some of these key words will very likely be found in the index. As related idioms are described as `UNDERLINING A STRING` and `UNDERLINING`

WORDS, key word UNDERLINING will show where a suitable idiom can be found.

### 3.2 How can decode T be used

Because the idiom list is sorted according to a functional order, most idioms using T are grouped in the same part of the list, near its beginning. Studying idioms in this way will help learning new ways of applying APL functions and thus widen the APL way of thinking.

### 3.3 Removing duplicate lines or elements

The index part contains several idioms under the keyword DUPLICATE. These idioms have been collected to the synonym list. By comparing these idioms it is possible to find an expression that will work properly and efficiently in the desired situation, like finding different words from a word matrix.

### 3.4 What does expression $A \circ . +, 0$ do

Idioms based on the outer product can easily be found in the idiom list. The verbal description of idiom  $X \circ . +, 0$  shows that this is a way to form a one-column matrix from a vector.

# TABLE OF FUNCTIONS

1	...	37	GRADE UP $\Delta$
38	...	44	GRADE DOWN $\nabla$
45	...	63	ENCODE $\tau$
64	...	84	DECODE $\downarrow$
85	...	101	EXECUTE $\pm$
102	...	111	FORMAT $\mp$
112	...	120	BRANCH $\rightarrow$
121	...	123	ROLL / DEAL $?$
124	...	128	MATRIX INVERSION / MATRIX DIVISION $\boxtimes$
129	...	134	GEOMETRICAL $\circ$
135	...	142	FACTORIAL / BINOMIAL $!$
143	...	204	OUTER PRODUCT $\cdot.\omega$
205	...	246	INNER PRODUCT $\alpha.\omega$
247	...	310	SCAN $\omega \backslash \omega \dagger$
311	...	374	REDUCTION $\omega / \omega \dagger$
375	...	412	TAKE $\uparrow$
413	...	448	DROP $\downarrow$
449	...	449	CEILING / MAXIMUM $\lceil$
450	...	462	FLOOR / MINIMUM $\lfloor$
463	...	479	MAGNITUDE / RESIDUE $ $
480	...	490	EXPAND $\backslash$
491	...	513	COMPRESS $/$
514	...	527	TRANSPOSE $\Phi$
528	...	537	REVERSE / ROTATE $\Phi \Theta$
538	...	548	MEMBER OF $\epsilon$
549	...	563	INDEX GENERATOR / INDEX OF $\iota$
564	...	569	LOGICAL $\sim \vee \wedge \neg \star$
570	...	575	COMPARISON $< \leq = \geq > \neq$
576	...	598	RAVEL / CATENATE $,$
599	...	609	AXIS / INDEXING $[$
610	...	618	SHAPE / RESHAPE $\rho$
619	...	628	ARITHMETIC $+ - \times \div$
629	...	631	MISCELLANEOUS

## IDIOM LIST

---

GRADE UP  $\Delta$ 

- 1  $L.5 \times (\Delta \Delta X) + \Phi \Delta \Delta \Phi X$  X←D1  
Ascending cardinal numbers (ranking, shareable)
- 2  $Y[A_1[\backslash A \leftarrow \Delta A[\Delta(+\backslash X)[A \leftarrow \Delta Y]]]]$  X←B1; Y←D1  
Maximum scan ( $\backslash$ ) over subvectors of Y indicated by X
- 3  $Y[A_1[\backslash A \leftarrow \Delta A[\Delta(+\backslash X)[A \leftarrow \nabla Y]]]]$  X←B1; Y←D1  
Minimum scan ( $\backslash$ ) over subvectors of Y indicated by X
- 4  $Y[\Delta Y] \wedge . = X[\Delta X]$  X←D1; Y←D1  
Test if X and Y are permutations of each other
- 5  $X[A[\Delta(+\backslash(\rho X) \epsilon + \backslash \square IO, Y)[A \leftarrow \Delta X]]]$  X←D1; Y←I1; ( $\rho X$ ) ↔ +/Y  
Sorting subvectors of lengths Y
- 6  $Y[A[X/\Delta(+\backslash X)[A \leftarrow \Delta Y]]]$  X←B1; Y←D1  
Minima ( $/$ ) of elements of subvectors of Y indicated by X
- 7  $A[\Delta(+\backslash X)[A \leftarrow \Delta Y]]$  X←B1; Y←D1  
Grading up subvectors of Y indicated by X
- 8  $(\rho X) \rho(, X)[\square IO + A[\Delta[A \div^{-1} \uparrow \rho X]]] \Delta A \leftarrow (\Delta, X) - \square IO$  X←D2  
Sorting rows of matrix X into ascending order
- 9  $(\rho X) \rho(, X)[A[\Delta(, \Phi(\Phi \rho X) \rho_1 \uparrow \rho X)[A \leftarrow \Delta, X]]]$  X←D2  
Sorting rows of matrix X into ascending order
- 10  $(\Delta \Delta(G+1), \rho \rho X) \Phi(Y, \rho X) \rho X$  G←I0; Y←I0; X←A  
Adding a new dimension after dimension G Y-fold
- 11  $(Y, X, Z, \dots)[\Delta \Delta G]$  X←A1; Y←A1; Z←A1; ... ; G←I1  
Merging X, Y, Z ... under control of G (mesh)
- 12  $(X, Y)[\Delta \Delta G]$  X←A1; Y←A1; G←B1  
Merging X and Y under control of G (mesh)
- 13  $\Delta \Delta X$  X←D1  
Ascending cardinal numbers (ranking, all different)
- 14  $Y[A[X/\Delta(+\backslash X)[A \leftarrow \nabla Y]]]$  X←B1; Y←D1  
Maxima ( $/$ ) of elements of subvectors of Y indicated by X
- 15  $A[\Delta(+\backslash X)[A \leftarrow \nabla Y]]$  X←B1; Y←D1  
Grading down subvectors of Y indicated by X
- 16  $(Y, X)[\Delta \nabla G]$  X←A1; Y←A1; G←B1  
Merging X and Y under control of G (mesh)
- 17  $\Delta \nabla X$  X←D1  
Descending cardinal numbers (ranking, all different)

- 18  $X[\Delta(1+pY)\downarrow Y\downarrow X;]$  X←A2; Y←A1  
Sorting rows of X according to key Y (alphabetizing)
- 19  $X[\Delta+\uparrow A\leftarrow-\Phi A\leftarrow X,0;]$  X←D2  
Sorting a matrix into lexicographic order
- 20  $X[\Delta X]^\wedge.\downarrow pX$  X←I1  
Test if X is a permutation vector
- 21  $Y[\Delta X++\backslash X]$  X←B1; Y←A1  
Rotate first elements (1Φ) of subvectors of Y indicated by X
- 22  $1\uparrow\Delta X$  X←D1  
Index of (first) minimum element of X
- 23  $\bar{1}\uparrow\Delta X$  X←D1  
Index of (first) maximum element of X
- 24  $X[(\Delta X)[\uparrow.5\times pX]]$  X←D1  
Median
- 25  $(X, ''')[(\square IO+pX)[\Delta(\downarrow pX), ('''=X)/\downarrow pX]$  X←C1  
Doubling quotes (for execution)
- 26  $(X, '*')[(\square IO+pX)[\Delta(\downarrow pX), (Y\times pG)pG]$  X←C1; Y←I0; G←I1  
Inserting Y \*'s into vector X after indices G
- 27  $(pX)\geq\Delta(\downarrow pX), Y$  X←D1; Y←I1  
Expansion vector with zero after indices Y
- 28  $(X, A_pH)[\Delta(\downarrow pX), A_pY] \Delta A\leftarrow G\times p, Y$  X←A1; Y←I1; G←I0; H←A0  
Catenating G elements H after indices Y in vector X
- 29  $((A_pH), X)[\Delta(A_pY), \downarrow pX] \Delta A\leftarrow G\times p, Y$  X←A1; Y←I1; G←I0; H←A0  
Catenating G elements H before indices Y in vector X
- 30  $\Delta Y\downarrow X$  Y←A1; X←A1  
Grade up according to key Y
- 31  $A \Delta A[\Delta G]\leftarrow A\leftarrow Y, X$  X←A1; Y←A1; G←B1  
Merging X and Y under control of G (mesh)
- 32  $X[\Delta Y[X]]$  X←I1; Y←D1  
Sorting indices X according to data Y
- 33  $X[\Delta X[\downarrow Y];]$  X←D2  
Sorting a matrix according to Y:th column
- 34  $\Delta X\times^{-1} 1[Y]$  X←D1; Y←I0  
Choosing sorting direction during execution
- 35  $X[\Delta X]$  X←D1  
Sorting X into ascending order

```

36  Y[ΔX]                                X←A1; Y←A1
    Sorting Y according to X

37  ΔX                                    X←I1
    Inverting a permutation

---
    GRADE DOWN  ∇

38  X[∇+!A<.-Q A←X,0;]                  X←D2
    Sorting a matrix into reverse lexicographic order

39  X[Φ∇+!(1pX)ε+!□IO,Y]                X←D1; Y←I1
    Reversal (Φ) of subvectors having lengths Y

40  Y[Φ∇+!X]                             X←B1; Y←A1
    Reversal (Φ) of subvectors starting at indices X

41  (+/X)↑∇X                             X←B1
    Indices of ones in logical vector X

42  X[∇' '≠X]                             X←C1
    Moving all blanks to end of text

43  X[∇Y]                                X←A1; Y←B1
    Moving elements satisfying condition Y to the start of X

44  X[∇X]                                X←D1
    Sorting X into descending order

---
    ENCODE  τ

45  ⚡101((1+[2⊙[/,X)ρ2)τX                X←I0
    Binary format of decimal number X

46  1 0⚡10 10τ1-□IO-1X                  X←I0
    Helps locating column positions 1..X

47  Φ((0,1pX)∘.=+!~A)+.x(-X)×.*A←((ρX)ρ2)τ-1+12*ρX  X←D1
    Polynomial with roots X

48  □IO+(ρX)τ-□IO-(,(X=(ρX)ρ[!X)∧X=Q(ΦρX)ρ[/X)/1×/ρX  X←D2
    Index pairs of saddle points

49  Q'0123456789ABCDEF'[□IO+(([/16⊙,X)ρ16)τX]        X←I
    Conversion from decimal to hexadecimal

50  (,X)/1+Aτ-1+1×/A←ρX                    X←C2
    Transforming connectivity matrix X into a connectivity list

51  □IO+(ρX)τ(1×/ρX)-□IO                  X←A
    Matrix of all indices of X

```

- 52  $(([2 \oplus 1 + X) \rho 2) \tau 0, 1X$  X ← I0  
All binary representations up to X (truth table)
- 53  $((1 + [10 \otimes X) \rho 10) \tau X$  X ← I0  
Digits of X separately
- 54  $((1 + [Y \otimes X) \rho Y) \tau X$  X ← D0; Y ← D0  
Representation of X in base Y
- 55  $\square IO + (\rho X) \tau (-\square IO) + (, X \in Y) / 1 \rho, X$  X ← A; Y ← A  
Indices of elements Y in array X
- 56  $, ' ', \Phi '0123456789ABCDEF' [\square IO + 16 \ 16 \tau - \square IO - \square AV, X]$  X ← C1  
Conversion of characters to hexadecimal representation ( $\square AV$ )
- 57  $\Phi (3 \rho 100) \tau X$  X ← D  
Separating a date YYMMDD to YY, MM, DD
- 58  $\square IO + (X, Y) \tau (1X \times Y) - \square IO$  X ← I0; Y ← I0  
All pairs of elements of 1X and 1Y
- 59  $((\rho X) \rho 2) \tau^{-1} + 12 * \rho X$  X ← A1  
Matrix for choosing all subsets of X (truth table)
- 60  $(X \rho 2) \tau^{-1} + 12 * X$  X ← I0  
All binary representations with X bits (truth table)
- 61  $1 + Y \tau X$  X ← D; Y ← D0  
Incrementing cyclic counter X with upper limit Y
- 62  $0 \ 1 \tau X$  X ← D  
Integer and fractional parts of positive numbers
- 63  $10 \ 100 \ 1000 \tau X$  X ← I  
Decoding numeric code ABBCCC into a matrix
- 
- DECODE 1
- 64  $A \Delta A[3 \ 6] \leftarrow ' : ' \Delta A \leftarrow \mp 1000 \ 13 \uparrow 3 \downarrow \square TS$   
Representation of current time (24 hour clock)
- 65  $A \Delta A[5 \ 8] \leftarrow ' - ' \Delta A \leftarrow \mp 1000 \ 13 \uparrow \square TS$   
Representation of current date (descending format)
- 66  $\rightarrow Y[1 + 21X]$  Y ← I1; X ← B1  
Case structure with an encoded branch destination
- 67  $G1Y \boxtimes X \cdot \cdot * \Phi - \square IO - 1 \rho X$  X ← D1; Y ← D1; G ← D0  
Interpolated value of series (X,Y) at G
- 68  $' * 0 \otimes' [\square IO + 21X \cdot \cdot \geq 1[ / , X]$  X ← I2; 1ppX ↔ 2  
Barchart of two integer series (across the page)

- 69  $(X \cdot \cdot +, 0) \downarrow Y$  X←D1; Y←D1  
Value of polynomial with coefficients Y at points X
- 70  $((A \downarrow A) = \downarrow p A + 2 \downarrow X \wedge \cdot = \Phi X) \uparrow X$  X←A2  
Removing duplicate rows
- 71  $B \rho A \Delta A[\square IO + B[1] \downarrow \square IO - X] \leftarrow 1 \Delta A \leftarrow (x/B \leftarrow 0 \ 0 + [/, X) \rho 0$  X←C2  
Transforming connectivity list X into a connectivity matrix
- 72  $100 \downarrow 100 \downarrow 3 \uparrow \square TS$   
Encoding current date
- 73  $(1 - ('' = X) \downarrow 1) \downarrow X$  X←C1  
Removing trailing blanks
- 74  $(12 \rho 7 \rho 31 \ 30)[X] - 0 \uparrow^{-1} + 2 \downarrow (X = 2), [.1] 0 \neq 4 \downarrow Y$  X←I0; Y←I  
Number of days in month X of year Y
- 75  $16 \downarrow \square IO - '0123456789ABCDEF' \downarrow \Phi X$  X←C  
Conversion from hexadecimal to decimal
- 76  $(1 - ('' = X) \downarrow 1) \Phi X$  X←C  
Justifying right
- 77  $(\div 1 + Y \div 100) \downarrow \Phi X$  X←D1; Y←D0  
Present value of cash flows X at interest rate Y %
- 78  $10 \downarrow^{-1} + '0123456789' \downarrow X$  X←C1  
Transformation of alphanumeric string into numeric
- 79  $('' = X) \downarrow 1$  X←C1  
Index of first non-blank, counted from the rear
- 80  $(, X)[\square IO + (\rho X) \downarrow Y - \square IO]$  X←A; Y←I2  
Indexing scattered elements
- 81  $\square IO + (\rho X) \downarrow Y - \square IO$  X←A; Y←I2  
Conversion of indices to indices of raveled array
- 82  $(1 + Y \div 100) \downarrow X$  X←D1; Y←D0  
Future value of cash flows X at interest rate Y %
- 83  $X \downarrow Y$  X←D0; Y←D  
Value of polynomial with coefficients Y at point X
- 84  $2 \downarrow X$  X←B  
Integer representation of logical vectors
- 
- EXECUTE  $\pm$
- 85  $\pm \pm '1', ' \uparrow \downarrow [\square IO + \wedge / (\rho X) = \Phi \rho X], '' '0 \sim 0 \in X = -\Phi X''$  X←D2  
Test for antisymmetry of matrix X

- 86  $\pm \pm '1', ' \uparrow \downarrow ' [\square IO + \wedge / (\rho X) = \Phi \rho X], ' ' ' 0 \sim 0 \epsilon X = \Phi X ' ' '$  X←A2  
Test for symmetricity of matrix X
- 87  $110 \oplus (\pm ('.' \neq A) / A \leftarrow \mp X) \div X$  X←D1  
Number of decimals of elements of X
- 88  $\pm 'VAR', (\mp X), ' \leftarrow Y'$  X←A0; Y←A  
Using a variable named according to X
- 89  $\pm X / ' \rightarrow '$  X←L0  
Conditional branch out of programs
- 90  $' * ' [\square IO + (\Phi (-1 + [ / A) + 11 + ([ / A) - [ / A) \cdot \cdot = A \leftarrow [ .5 + \pm F]$  F←A1; X←D1  
Graph of F(X) at points X ('X'∈F)
- 91  $A + . \times \pm F, 0 \rho X \leftarrow Y[1] + (A \leftarrow - / Y \div G) \times 0, 1 G$  F←A1; G←D0; Y←D1;  $\rho Y \leftrightarrow 2$   
Definite integral of F(X) in range Y with G steps ('X'∈F)
- 92  $X \leftarrow \pm, ((2 \uparrow 'X'), ' ', [.5] A) [\square IO + \sim ' ' \wedge = A \leftarrow, \square; ]$   
Changing X if a new input value is given
- 93  $(X \vee . \neq ' ' ) \setminus 1 \downarrow \pm ' 0 ' ', X, ' '$  X←C2  
Conversion of each row into a number (default zero)
- 94  $\pm ((X \wedge = ' ' ) / ' Y ' ), X$  X←D1  
Converting expression X to numeric form with default value Y
- 95  $1 \downarrow \pm ' 0 ' ', (\wedge / X \epsilon ' 0123456789 ' ) / X$  X←C1  
Test if numeric and converting into numeric form
- 96  $\pm X / ' EXPRESSION '$  X←B0  
Conditional execution
- 97  $1 \rho (\pm \square, ' ', 10 ' ), X$  X←D0  
Giving a numeric default value for input
- 98  $A \leftarrow \pm, ' ', ' ( ' , ' 0 ' , ' \rho ' , Y, ' \leftarrow ' , X, ' ' )'$  X←C2; Y←C2  
Assign values of expressions in X to variables named in Y
- 99  $\pm, ' ', ' ', ' ( ' , ' ', ' X, ' ' )'$  X←A  
Evaluation of several expressions; results form a vector
- 100  $\pm ' X [ ' , ((-1 + \rho \rho X) \rho ' ; ' ), ' Y ]'$  X←A; Y←I  
Indexing when rank is not known beforehand
- 101  $\pm, ' + ', X$  X←A2  
Sum of numbers in character matrix X
- 
- FORMAT  $\mp$
- 102  $(3 \Phi 7 \ 0 \mp X \cdot \cdot +, 0), \mp Y$  X←D1; Y←A2  
Numeric headers (elements of X) for rows of table Y

- 103  $\overline{p}X \cdot .+, 0$  X←D1  
*Formatting a numerical vector to run down the page*
- 104  $A \Delta A[(\text{' '}=A)/\text{' '}_pA] \leftarrow \text{' '}$   $\Delta A \leftarrow \overline{p}03 \uparrow \square TS$   
*Representation of current date (ascending format)*
- 105  $(, (0 \text{ } 1 \downarrow 3 \text{ } 0 \overline{p}100+3 \text{ } 1 \text{ } p12 \text{ } 0 \text{ } 0 \text{ } | 3 \uparrow 3 \downarrow \square TS), \text{' ': '}), \text{'AP'}[1+12 \leq \square TS[4]], \text{'M'}$   
*Representation of current time (12 hour clock)*
- 106  $0 \text{ } 1 \downarrow (2 \uparrow Y+1) \overline{p}(10 \times Y) + ((\text{' '}_pX), 1) \text{ } pX$  X←I1; Y←I0  
*Leading zeroes for positive numbers X in fields of width Y*
- 107  $A \Delta A[(\text{' '}=A)/\text{' '}_pA] \leftarrow \text{' '/'}$   $\Delta A \leftarrow \overline{p}100 | 1 \overline{p}03 \uparrow \square TS$   
*Representation of current date (American)*
- 108  $(\text{' '}_pA) \text{ } pB \setminus (B \leftarrow, (\text{' '}_0 \neq A) \vee \text{' '}_\neq 1 \overline{p}A) / , A \leftarrow \text{' '}$  X←A  
*Formatting with zero values replaced by blanks*
- 109  $((1, G) \times \text{' '}_pX) \text{ } p2 \text{ } 1 \text{ } 3 \overline{p}(\text{' '}_pG, \text{' '}_pX) \text{ } p(, G, [1.1]Y) \overline{p}X$  X←D2; Y←I1; G←I0  
*Row-by-row formatting (width G) of X with Y decimals per row*
- 110  $(, G, [1.1]H) \overline{p}X$  X←D; G←I1; H←I1  
*Formatting X with H decimals in fields of width G*
- 111  $\text{' '}_pX$  X←D0  
*Number of digit positions in scalar X (depends on  $\square PP$ )*
- BRANCH →
- 112  $\rightarrow \square LC \uparrow \text{' '}_\vee / , (X \leftarrow X \vee X \vee . \wedge X) \neq +X$  X←B2  
*Forming a transitive closure*
- 113  $\rightarrow Y \uparrow \text{' '}_G \geq X \leftarrow X+1$  X←I0; Y←I0; G←I0  
*For-loop ending construct*
- 114  $\rightarrow Y \uparrow \text{' '}_X$  X←B0; Y←I0  
*Conditional branch to line Y*
- 115  $\rightarrow X/Y$  X←B1; Y←I1  
*Case structure with logical switch (preferring from start)*
- 116  $\rightarrow X \overline{p}Y$  X←I0; Y←I1  
*Case structure with integer switch*
- 117  $\rightarrow Y[G \text{ }_1 X]$  X←A0; Y←I1; G←A1  
*Case structure according to key vector G*
- 118  $\rightarrow 0 \times \text{' '}_1 X$  X←B0  
*Conditional branch out of program*
- 119  $\rightarrow Y[2 + \times X]$  X←I0; Y←I1  
*Conditional branch depending on sign of X*

120  $\rightarrow Y \times X$  X←D0; Y←I0  
Continuing from line Y (if X>0) or exit

---  
ROLL / DEAL ?

121  $X[1] \leftarrow ?Y_p \rightarrow / X$  X←I1; Y←I1  
Y-shaped array of random numbers within ( X[1], X[2] ]

122  $?Y_p X$  Y←I; X←I  
Choosing Y objects out of X with replacement (roll)

123  $Y ? X$  X←I0; Y←I0  
Choosing Y objects out of X without replacement (deal)

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MATRIX INVERSION / MATRIX DIVISION  $\boxtimes$

124  $*A + .x(\boxtimes Y) \boxtimes A \leftarrow X \cdot .x0 \ 1$  X←D1; Y←D1  
Predicted values of exponential (curve) fit

125  $A + .xY \boxtimes A \leftarrow X \cdot .x0 \ 1$  X←D1; Y←D1  
Predicted values of best linear fit (least squares)

126  $\boxtimes Y \boxtimes X \cdot .x0, \ 1G$  X←D1; Y←D1  
G-degree polynomial (curve) fit of points (X,Y)

127  $A \Delta A[1] \leftarrow *A[1] \Delta A \leftarrow (\boxtimes Y) \boxtimes X \cdot .x0 \ 1$  X←D1; Y←D1  
Coefficients of exponential (curve) fit of points (X,Y)

128  $Y \boxtimes X \cdot .x0 \ 1$  X←D1; Y←D1  
Best linear fit of points (X,Y) (least squares)

---  
GEOMETRICAL  $\circ$

129  $((X \neq 0) \times^{-3} oY \div X + X = 0) + o((X = 0) \times .5 \times Y) + (X < 0) \times 1 - 2 \times Y < 0$  X←D; Y←D  
Arctan  $Y \div X$

130  $1 \ 2 \times .oX, Y$  X←D0, Y←D0  
A way to combine trigonometric functions (sin X cos Y)

131  $o /^{-2} 1, X$  X←D0  
Complementary angle (arccos sin X)

132  $2 \ 2p1 \ ^{-1} 1 \ 1 \times 2 \ 1 \ 1 \ 2oX$  X←D0  
Rotation matrix for angle X (in radians) counter-clockwise

133  $X \times 180 \div o1$  X←D  
Transformation from radians to degrees

134  $X \times o \div 180$  X←D  
Transformation from degrees to radians

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## FACTORIAL / BINOMIAL !

- 135  $(Y)!X$  X←D; Y←D  
Number of permutations of X objects taken Y at a time
- 136  $\Phi A \cdot !A \div 0, 1X$  X←I0  
Pascal's triangle of order X (binomial coefficients)
- 137  $+ / Y \times (X \cdot A) \div !A \leftarrow -1 + 1pY$  X←D0; Y←D1  
Value of Taylor series with coefficients Y at point X
- 138  $(A!X) \times (Y \cdot A) \times (1-Y) \cdot X - A \leftarrow -10 - 1X + 1$  X←I0; Y←D0  
Binomial distribution of X trials with probability Y
- 139  $\div Y \times (X-1)!Y + X-1$  X←D0; Y←D0  
Beta function
- 140  $(-Y) \times (Y \cdot X) \div !X$  X←I; Y←D0  
Poisson distribution of states X with average number Y
- 141  $!X-1$  X←D0  
Gamma function
- 142  $Y!X$  X←D; Y←D  
Number of combinations of X objects taken Y at a time

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OUTER PRODUCT  $\cdot \cdot \omega$ 

- 143  $\Phi X \cdot \cdot = (1 \ 1 \Phi \setminus X \cdot \cdot = X) / X$  X←D1  
'Position' matrix of a vector
- 144  $' \square' [ \square 10 + (\Phi 1 \uparrow / A) \cdot \cdot \leq A \leftarrow + / (1 + ([ / X] - [ / X] \cdot \cdot = X) ]$  X←I1  
Histogram (distribution barchart; down the page)
- 145  $+ / ((-1 \downarrow Y) \cdot \cdot \leq X) \wedge (1 \downarrow Y) \cdot \cdot > X$  X←D; Y←D1  
Distribution of X into intervals between Y
- 146  $Y \cdot \cdot \times (1 + G \div 100) \cdot \cdot \times X$  X←D; Y←D; G←D  
Compound interest for principals Y at rates G % in times X
- 147  $(Y[A \cdot \cdot + -1 + 1pX] \wedge \cdot \cdot = X) / A \leftarrow (A = 1 \uparrow X) / 1pA \leftarrow (1 - pX) \downarrow Y$  X←A1; Y←A1  
Occurrences of string X in string Y
- 148  $(1 \ -1 \cdot \cdot = \Phi X) + \cdot \cdot \times 1 \uparrow pX$  X←I2 (1=START; -1=END)  
Transforming connection matrix X into a node matrix
- 149  $0 + \cdot \cdot \neq ([ (10 \cdot Y) \times 10 \cdot \square 10 - 1Y + 1) \cdot \cdot ] [ X \times 10 \cdot Y$  X←D; Y←I0  
Number of decimals (up to Y) of elements of X
- 150  $X + \cdot \cdot \times Y \cdot \cdot = ((1pY) = Y \downarrow Y) / Y$  X←D1 Y←D1  
Sum over elements of X determined by elements of Y

- 151  $(F\ A)+.x(A+((1pX)=X1X)/X)0.=X$  X←A1  
Executing costly monadic function F on repetitive arguments
- 152  $(G0.=X)+.xY$  X←A; Y←D; G←A  
Sums according to codes G
- 153  $1++/\wedge 1\ 2\ 1\ 3\ 0Y0.=X$  X←A2; Y←A2  
'X1Y' by rows for elements of matrices
- 154  $(1\ 1\ 0<X0.=X)/X$  X←A1  
Removing duplicate elements (nub)
- 155  $[/(\wedge 0=A0.=X)/A+11/X$  X←I1  
Greatest common divisor of elements of X
- 156  $+/((A\times X\div[/A+Y-[/Y)0.\geq^{-1}+1X$  X←I0; Y←D1  
Classification of elements Y into X classes of equal size
- 157  $-/(1[/X)0.=0X$  X←I2 (X[1;]=START; X[2;]=END)  
Transforming node matrix X into a connection matrix
- 158  $\wedge/1=+/X0.=1pX$  X←I1  
Test if X is a permutation vector
- 159  $v/\wedge 0\ 10.=X$  X←B1  
Test if all elements of vector X are equal
- 160  $(pX)p(,(+/A)0.>-\square IO-1^{-1}1pX)\backslash(,A+X\neq' ')/,X$  X←C  
Moving all blanks to end of each row
- 161  $\wedge/,(0\neq X)\leq A0.\leq A+111pX$  X←D2  
Test if X is an upper triangular matrix
- 162  $\wedge/,(0\neq X)\leq A0.\geq A+111pX$  X←D2  
Test if X is a lower triangular matrix
- 163  $+f(\square IO-1pX)\Phi X0.\times Y,0\times 11X$  X←D1; Y←D1  
Product of two polynomials with coefficients X and Y
- 164  $0=(1[/X)0.=1X$  X←I1  
Divisibility table
- 165  $X0.<\Phi 1[/X$  X←I1  
Matrix with X[i] trailing zeroes on row i
- 166  $' \square '[\square IO+(\Phi 1[/X)0.\leq X]$  X←I1  
Barchart of integer values (down the page)
- 167  $X0.\geq\Phi 1[/X$  X←I1  
Matrix with X[i] trailing ones on row i
- 168  $X0.<1[/X$  X←I1  
Matrix with X[i] leading zeroes on row i

- 169  $X \cdot \geq \lceil /X, 0$  X←I1  
*Comparison table*
- 170  $' \square' [\square IO + X \cdot \geq (\lceil /X) \times (\lceil Y) \div Y]$  X←D1; Y←D0  
*Barchart of X with height Y (across the page)*
- 171  $' \square' [\square IO + X \cdot \geq \lceil /X]$  X←I1  
*Barchart of integer values (across the page)*
- 172  $X \cdot \geq \lceil /X$  X←I1  
*Matrix with X[i] leading ones on row i*
- 173  $+ / (\lceil Y) \cdot = [ (X - G) \div H$  X←D; Y←I0; G←D0; H←D0  
*Division to Y classes with width H, minimum G*
- 174  $1 \ 2 \ 1 \oplus X \cdot - \lceil /X$  X←D2  
*Move set of points X into first quadrant*
- 175  $(2 = + / 0 = (\lceil X) \cdot \lceil \lceil X) / \lceil X$  X←I0  
*All primes up to X*
- 176  $(\wedge f(\neg 1 + \lceil pX) \oplus (X \cdot = Y), 0) / \lceil 1 + pY$  X←C1; Y←C1  
*Occurrences of string X in string Y*
- 177  $\square IO + + / Y \cdot \geq (' ' = X) / \lceil pX$  X←C1; Y←I  
*Ordinal numbers of words in X that indices Y point to*
- 178  $(\wedge f(\neg 1 + \lceil pX) \oplus X \cdot = Y) \lceil 1$  X←A1; Y←A1  
*First occurrence of string X in string Y*
- 179  $Y[+ / Y \cdot \leq X]$  X←D0; Y←D1  
*Contour levels Y at points with altitudes X*
- 180  $\neq / X \cdot \geq Y$  X←D; Y←D1  
*Test if X is within range [ Y[1], Y[2] )*
- 181  $+ / X \cdot \geq 0 \ 50 \ 100 \ 1000$  X←D  
*Which class do elements of X belong to*
- 182  $((\neg 1 \oplus \sim A) \wedge A \leftarrow (\neg 1 \downarrow X = 1 \oplus X), 0) / Y \cdot = Y$  X←A1; Y←A1  
*Repeat matrix*
- 183  $(\lceil X) \cdot \lceil \lceil X$  X←I0  
*Maximum table*
- 184  $(, Y \cdot > \oplus (\lceil G) - \square IO) \backslash X$  X←A1; Y←I1; G←I0  
*Justifying right fields of X (lengths Y) to length G*
- 185  $(, Y \cdot > (\lceil G) - \square IO) \backslash X$  X←A1; Y←I1; G←I0  
*Justifying left fields of X (lengths Y) to length G*
- 186  $((pA)pY \div 100) \div A \leftarrow \oplus 1 - (1 + Y \div 100) \cdot \cdot - X$  X←I; Y←D  
*Annuity coefficient; X periods at interest rate Y %*

- 187 1 3 2 4  $\Phi X \cdot \cdot \times Y$   $X \leftarrow D2; Y \leftarrow D2$   
Direct matrix product
- 188 1 2 1 2  $\Phi X \cdot \cdot \times Y$   $X \leftarrow D2; Y \leftarrow D2$   
Shur product
- 189 1 2 2  $\Phi Y \cdot \cdot + X$   $X \leftarrow D1; Y \leftarrow D2$   
Adding X to each row of Y
- 190 2 1 2  $\Phi X \cdot \cdot + Y$   $X \leftarrow D1; Y \leftarrow D2$   
Adding X to each row of Y
- 191 1 2 1 2  $\Phi X \cdot \cdot + Y$   $X \leftarrow D2; Y \leftarrow D2$   
Matrix sum
- 192 1 2 1  $\Phi Y \cdot \cdot + X$   $X \leftarrow D1; Y \leftarrow D2$   
Adding X to each column of Y
- 193 1 1 2  $\Phi X \cdot \cdot + Y$   $X \leftarrow D1; Y \leftarrow D2$   
Adding X to each column of Y
- 194  $G \Phi X \cdot \cdot \alpha Y$   $X \leftarrow A; Y \leftarrow A; G \leftarrow I1$   
Selecting specific elements from a 'large' outer product
- 195  $(1X) \cdot \cdot \leq 1X$   $X \leftarrow I0$   
 $X \times X$  upper triangular matrix
- 196  $(1X) \cdot \cdot \geq 1X$   $X \leftarrow I0$   
 $X \times X$  lower triangular matrix
- 197  $(1X) \cdot \cdot = 1X$   $X \leftarrow I0$   
 $X \times X$  identity matrix
- 198  $+^{-1} + (1X) \cdot \cdot + 1X$   $X \leftarrow I0$   
Hilbert matrix of order X
- 199  $(1X) \cdot \cdot \times 1X$   $X \leftarrow I0$   
Multiplication table
- 200  $X[; , (Yp1) \cdot \cdot \times 1(pX)[2]; ]$   $Y \leftarrow I0; X \leftarrow A3$   
Replicating a dimension of rank three array X Y-fold
- 201  $(0, 1(pX) - Y) \cdot \cdot + Y$   $X \leftarrow A1 Y \leftarrow I0$   
Moving index of width Y for vector X
- 202  $X \cdot \cdot + 1Y$   $X \leftarrow I1; Y \leftarrow I0$   
Indices of subvectors of length Y starting at X+1
- 203  $X \cdot \cdot + , 0$   $X \leftarrow D1$   
Reshaping numeric vector X into a one-column matrix
- 204  $X \cdot \cdot \times 1^{-1}$   $X \leftarrow D$   
Array and its negative ('plus minus')

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## INNER PRODUCT a.w

- 205  $(-2 \uparrow + / \wedge \backslash \Phi X \wedge . = ' ' ) \downarrow X$  X←C2  
Removing trailing blank rows
- 206  $((A_1 A) = \downarrow \rho A \leftarrow \square IO \uparrow + \uparrow \wedge \backslash X v . \neq \Phi X) \uparrow X$  X←A2  
Removing duplicate rows
- 207  $\square IO \uparrow + \uparrow \wedge \backslash X v . \neq \Phi Y$  X←A2; Y←A2  
'X<sub>1</sub>Y' for rows of matrices
- 208  $(1 \ 1 \Phi \backslash X \wedge . = \Phi X) \uparrow X$  X←A2  
Removing duplicate rows
- 209  $(\Phi v \backslash \Phi ' ' v . \neq X) / X$  X←C2  
Removing trailing blank columns
- 210  $(v \backslash ' ' v . \neq X) / X$  X←C2  
Removing leading blank columns
- 211  $(v \backslash X v . \neq ' ' ) \uparrow X$  X←C2  
Removing leading blank rows
- 212  $(X[1 \downarrow A])[1 \uparrow A \leftarrow (2 \ 2 \rho^{-1} \ 1 \ 1 \ ^{-1}) + . \times 10 * (-1 \downarrow Y), - / Y + Y > 99 \ 0 \ X \leftarrow D; Y \leftarrow I1$   
Limits X to fit in  $\mathbb{F}$  field Y[1 2]
- 213  $A + (X - A \leftarrow \downarrow / X) \uparrow . \times Y$  X←A1; Y←B  
Maxima of elements of subsets of X specified by Y
- 214  $X \wedge . = v / X$  X←B1  
Test if all elements of vector X are equal
- 215  $X \wedge . = \wedge / X$  X←B1  
Test if all elements of vector X are equal
- 216  $((((1 \uparrow \rho X), \rho Y) \uparrow X) \wedge . = Y) \uparrow X$  X←A2; Y←A1  
Rows of matrix X starting with string Y
- 217  $(' ' \neq X) \uparrow . \times \downarrow^{-1} \uparrow \rho X$  X←C  
Indices of last non-blanks in rows
- 218  $(A v \downarrow 1 \Phi 1, A \leftarrow X v . \neq ' ' ) \uparrow X$  X←C2  
Removing duplicate blank rows
- 219  $((-A) \downarrow X \wedge . = (A, 1 + \rho Y) \rho Y) / \downarrow (\rho Y) + 1 - A + \rho X$  X←A1; Y←A1  
Occurrences of string X in string Y
- 220  $(A v \downarrow 1, \downarrow^{-1} \uparrow A \leftarrow ' ' v . \neq X) / X$  X←C2  
Removing duplicate blank columns
- 221  $\sim X \leq . \geq ([X]), G, H$  X←I0; G←I0; H←I0  
Test if X is an integer within range [ G, H )

- 222  $Y \uparrow . \times X$  X←D1; Y←D1  
Maximum of X with weights Y
- 223  $Y \downarrow . \times X$  X←D1; Y←D1  
Minimum of X with weights Y
- 224  $X \leftarrow X \downarrow . + X$  X←B2  
Extending a distance table to next leg
- 225  $(X \vee . \neq ' ') \uparrow X$  X←C2  
Removing blank rows
- 226  $(' ' \vee . \neq X) / X$  X←C2  
Removing blank columns
- 227  $(X *^{-1} + 1 \uparrow p Y) + . \times \Phi Y$  X←D0; Y←D  
Value of polynomial with coefficients Y at point X
- 228  $1 \in X \wedge . = Y$  X←A; Y←A1  
Test if vector Y is a row of array X
- 229  $(Y \wedge . = X) \downarrow 1$  X←A2; Y←A1;  $^{-1} \uparrow p Y \leftrightarrow p X$   
First occurrence of string X in matrix Y
- 230  $X \leftarrow X \vee . \wedge X$  X←B2  
Extending a transitive binary relation
- 231  $X \vee . \neq Y$  X←A; Y←A0  
Test if rows of X contain elements differing from Y
- 232  $X \wedge . = Y$  X←A; Y←A1  
Comparing vector Y with rows of array X
- 233  $X < . < Y$  X←D0; Y←D2;  $1 \uparrow p Y \leftrightarrow 2$   
Test if X is within range [ Y[1;], Y[2;] ]
- 234  $X < . \leq Y$  X←D; Y←D2;  $1 \uparrow p Y \leftrightarrow 2$   
Test if X is within range ( Y[1;], Y[2;] ]
- 235  $(X, [ . 1 + p p X ] X) > . > Y$  X←D; Y←D2;  $1 \uparrow p Y \leftrightarrow 2$   
Test if X is within range ( Y[1;], Y[2;] ]
- 236  $X + . = , Y$  X←A0; Y←A  
Number of occurrences of scalar X in array Y
- 237  $(Y + . \times X) \div p X$  X←D1; Y←D1  
Arithmetic average (mean value) of X weighted by Y
- 238  $Y - . \div X$  X←D1; Y←D1  
Sum of alternating reciprocal series  $Y \div X$
- 239  $Y + . \div X$  X←D1; Y←D1  
Sum of reciprocal series  $Y \div X$

- 240  $X+.xY$   $X \leftarrow D$ ;  $Y \leftarrow D$ ;  $^{-1} \uparrow pX \leftrightarrow 1 \uparrow pY$   
Matrix product
- 241  $X+.xY$   $X \leftarrow A1$ ;  $Y \leftarrow B$   
Summation over subsets of  $X$  specified by  $Y$
- 242  $X+.xX$   $X \leftarrow D1$   
Sum of squares of  $X$
- 243  $Y+.xX$   $X \leftarrow D1$ ;  $Y \leftarrow D1$   
Scalar (dot) product of vectors
- 244  $Xx.xY$   $X \leftarrow A1$ ;  $Y \leftarrow B$   
Products over subsets of  $X$  specified by  $Y$
- 245  $\square RL \leftarrow \square TS+.x2$   
Randomizing random numbers (in  $\square LX$  in a workspace)
- 246  $X+.x2$   $X \leftarrow D1$   
Sum of squares of  $X$
- SCAN  $\omega \setminus \omega \dagger$
- 247  $(1+/X,Y) \epsilon + \setminus 1 + ^{-1} \downarrow 0, ((1+/X) \epsilon + \setminus X) \setminus Y$   $Q \leftarrow I1$ ;  $Y \leftarrow I1$   
Vector  $(X[1]p1), (Y[1]p0), (X[2]p1), \dots$
- 248  $(A-[0.5 \times (A++/\wedge \setminus \Phi A)++/\wedge \setminus A \leftarrow ' '= \Phi X) \Phi X$   $X \leftarrow C$   
Centering character array  $X$  with ragged edges
- 249  $\square IO++ \setminus 1 + ((1+/X) \epsilon + \setminus \square IO, X) \setminus Y - ^{-1} \downarrow 1, X+Y$   $X \leftarrow I1$ ;  $Y \leftarrow I1$ ;  $pX \leftrightarrow pY$   
Vector  $(Y[1]+\setminus X[1]), (Y[2]+\setminus X[2]), (Y[3]+\setminus X[3]), \dots$
- 250  $Y[\setminus (1+/X) \epsilon ^{-1} \downarrow 1++ \setminus 0, X]$   $X \leftarrow I1$ ;  $Y \leftarrow A1$ ;  $\wedge / 0 < X$   
Replicate  $Y[i]$   $X[i]$  times (for all  $i$ )
- 251  $((X \neq 0)/Y)[\setminus ^{-1} \Phi (1+/X) \epsilon + \setminus X]$   $X \leftarrow I1$ ;  $Y \leftarrow A1$   
Replicate  $Y[i]$   $X[i]$  times (for all  $i$ )
- 252  $\neq \setminus (1+/X) \epsilon + \setminus \square IO, X$   $X \leftarrow I1$ ;  $\wedge / 0 < X$   
Vector  $(X[1]p1), (X[2]p0), (X[3]p1), \dots$
- 253  $Y[\square IO++ \setminus (1+/X) \epsilon \square IO++ \setminus X]$   $X \leftarrow I1$ ;  $Y \leftarrow A1$ ;  $\wedge / 0 < X$   
Replicate  $Y[i]$   $X[i]$  times (for all  $i$ )
- 254  $\neq \setminus Y \neq X \setminus A \neq ^{-1} \downarrow 0, A \leftarrow X / \neq \setminus ^{-1} \downarrow 0, Y$   $X \leftarrow B1$ ;  $Y \leftarrow B1$   
Running parity ( $\neq \setminus$ ) over subvectors of  $Y$  indicated by  $X$
- 255  $+ \setminus Y - X \setminus A - ^{-1} \downarrow 0, A \leftarrow X / + \setminus ^{-1} \downarrow 0, Y$   $X \leftarrow B1$ ;  $Y \leftarrow D1$   
Cumulative sum ( $+$ ) over subvectors of  $Y$  indicated by  $X$
- 256  $Y \wedge A = [\setminus X \times A++ \setminus Y > ^{-1} \downarrow 0, Y$   $X \leftarrow B$ ;  $Y \leftarrow B$   
Groups of ones in  $Y$  pointed by  $X$  (or trailing parts)

- 257  $A \leftarrow -1 \downarrow 0, A \leftarrow (+ \setminus X)[+ \setminus Y]$   $X \leftarrow D1; Y \leftarrow I1$   
Sums over (+/) subvectors of X, lengths in Y
- 258  $(\rho X) \rho A \setminus (A \leftarrow, \wedge \setminus (' \# X) \vee \# \setminus X = ''') / , X$   $X \leftarrow C2$   
Decommenting a matrix representation of a function ( $\square CR$ )
- 259  $((\Phi \vee \setminus \Phi A) \wedge \vee \setminus A \leftarrow ' \# X) / X$   $X \leftarrow C1$   
Removing leading and trailing blanks
- 260  $+ \setminus + \setminus i X$   $X \leftarrow I0$   
X first figurate numbers
- 261  $X \wedge \wedge \setminus X = \vee \setminus X$   $X \leftarrow B$   
First group of ones
- 262  $(\setminus, (X = (\rho X) \rho [ \setminus X) \wedge X = \Phi (\Phi \rho X) \rho [ \setminus X) / , X$   $X \leftarrow D2$   
Value of saddle point
- 263  $((\sim (\rho A \uparrow X) \uparrow ' / ' = Y) / A \uparrow X), (1 \downarrow A \downarrow Y), (A \leftarrow + / \wedge \setminus Y \# ' , ' ) \downarrow X$   $X \leftarrow C1; Y \leftarrow C1$   
Editing X with Y  $\nabla$ -wise
- 264  $((i(\rho Y)++/X) \epsilon + \setminus 1 \downarrow 0, -1 \downarrow ((i(\rho Y) \epsilon G) \setminus X) \setminus Y$   $X \leftarrow I1; Y \leftarrow A1; G \leftarrow I1$   
Open a gap of X[i] after Y[G[i]] (for all i)
- 265  $(i(\rho Y)++/X) \epsilon + \setminus 1 + -1 \downarrow 0, (1 \Phi Y) \setminus X$   $X \leftarrow I1; Y \leftarrow B1$   
Insert vector for X[i] zeroes after i:th subvector
- 266  $(-+ / \wedge \setminus ' \# \Phi X) \downarrow X$   $X \leftarrow C1$   
Removing trailing blanks
- 267  $(+ / \wedge \setminus ' \# X) \downarrow X$   $X \leftarrow C1$   
Removing leading blanks
- 268  $\wedge / [Y] X = [ \setminus [Y] X$   $X \leftarrow D; Y \leftarrow I0$   
Test if X is in ascending order along direction Y
- 269  $(- [ 0.5 \times + / \wedge \setminus ' \# \Phi X) \Phi X$   $X \leftarrow C$   
Centering character array X with only right edge ragged
- 270  $\wedge / [Y] X = [ \setminus [Y] X$   $X \leftarrow D; Y \leftarrow I0$   
Test if X is in descending order along direction Y
- 271  $((i(\rho Y)++/X) \epsilon + \setminus 1 + ((i(\rho Y) \epsilon G) \setminus X) \setminus Y$   $X \leftarrow I1; Y \leftarrow A1; G \leftarrow I1$   
Open a gap of X[i] before Y[G[i]] (for all i)
- 272  $(\Phi \vee \setminus \Phi \vee \setminus ' \# X) / X$   $X \leftarrow C2$   
Removing trailing blank columns
- 273  $X, [ \square I0 - (\ast \setminus 2 \rho \wedge / 2 > (\rho \rho X), \rho \rho Y) / .5 \ 0 ] Y$   $X \leftarrow A; Y \leftarrow A$   
Vectors as matrices in catenation
- 274  $X, [ \square I0 + (\ast \setminus 2 \rho \wedge / 2 > (\rho \rho X), \rho \rho Y) / .5 \ 1 ] Y$   $X \leftarrow A; Y \leftarrow A$   
Vectors as matrices in catenation

- 275  $(-+/\wedge\backslash' '= \Phi X)\Phi X$  X←C  
Justifying right
- 276  $(+/\wedge\backslash' '= X)\Phi X$  X←C  
Justifying left
- 277  $(1+/X)\epsilon(+\backslash X) \sim \square IO$  X←I1  
Changing lengths of subvectors to ending indicators
- 278  $(1+/X)\epsilon+\backslash \square IO, X$  X←I1  
Changing lengths of subvectors to starting indicators
- 279  $(1+/A)\epsilon+\backslash A+1+X$  X←I1  
Insert vector for X[i] elements before i:th element
- 280  $(+\backslash X)11+/X$  X←B1  
Indices of ones in logical vector X
- 281  $+/Y \times \backslash 1, X \div 1^{-1} + pY$  X←D0; Y←D1  
Value of Taylor series with coefficients Y at point X
- 282  $\square IO++/\wedge\backslash' '\neq X$  X←C  
Indices of first blanks in rows of array X
- 283  $(Y=+\backslash X=1\uparrow X)/X$  Y←I0; X←C1  
Locating field number Y starting with first element of X
- 284  $A^{-1}\downarrow 0, A \leftarrow (Y \neq 1 \downarrow Y, 0) / + \backslash X$  X←D1; Y←D1  
Sum elements of X marked by succeeding identicals in Y
- 285  $((Y-1)\downarrow A) - 0, (-Y)\downarrow A \leftarrow + \backslash X$  X←D1; Y←I0  
Running sum of Y consecutive elements of X
- 286  $G^{-1}\downarrow 0, G \leftarrow 0[(+\backslash Y) - X$  Y←D1; X←D0  
Fifo stock Y decremented with X units
- 287  $A v^{-1}\downarrow 0, A \leftarrow 2|+\backslash X = ''''$  X←C1  
Locations of texts between and including quotes
- 288  $A \wedge^{-1}\downarrow 0, A \leftarrow 2|+\backslash X = ''''$  X←C1  
Locations of texts between quotes
- 289  $\neq \backslash (Y \vee X) \backslash A \neq^{-1}\downarrow 0, A \leftarrow (Y \vee X) / Y$  X←B1; Y←B1  
Or-scan ( $\vee$ ) over subvectors of Y indicated by X
- 290  $\sim \neq \backslash (Y \leq X) \backslash A \neq^{-1}\downarrow 0, A \leftarrow \sim (Y \leq X) / Y$  X←B1; Y←B1  
And-scan ( $\wedge$ ) over subvectors of Y indicated by X
- 291  $A^{-1}\downarrow 0, A \leftarrow (1\Phi X) / + \backslash Y$  X←B1; Y←D1  
Sums over (+/) subvectors of Y indicated by X
- 292  $Y \wedge A \epsilon (X \wedge Y) / A \leftarrow + \backslash Y >^{-1}\downarrow 0, Y$  X←B1; Y←B1  
Groups of ones in Y pointed by X

- 293  $A \vee^{-1} \downarrow 0, A \neq \backslash X = ''''$  X←C1  
*Locations of texts between and including quotes*
- 294  $A \wedge^{-1} \downarrow 0, A \neq \backslash X = ''''$  X←C1  
*Locations of texts between quotes*
- 295  $+\backslash ((' (=X) -^{-1} \downarrow 0, ')') = X$  X←C1  
*Depth of parentheses*
- 296  $+\backslash^{-1} \downarrow \square I O, X$  X←I1  
*Starting positions of subvectors (lengths in X)*
- 297  $X[1[[\backslash Y \times i p Y]$  X←A1; Y←B1  
*Duplicating element of X belonging to Y, 1↑X until next found*
- 298  $(\Phi \vee \backslash \Phi' ' \neq X) / X$  X←C1  
*Removing trailing blanks*
- 299  $(\vee \backslash ' ' \neq X) / X$  X←C1  
*Removing leading blanks*
- 300  $(G = + \backslash X) / Y$  X←A1; Y←B1; G←I0  
*G:th subvector of Y (subvectors indicated by X)*
- 301  $-\backslash \backslash X$  X←I0  
*Alternating series (1 <sup>-1</sup> 2 <sup>-2</sup> 3 <sup>-3</sup> ...)*
- 302  $+\backslash \backslash X$  X←I0  
*X first triangular numbers*
- 303  $X \vee \neq \backslash X$  X←B  
*Joining pairs of ones*
- 304  $\vee \backslash X$  X←B  
*Turn on all zeroes after first one*
- 305  $(\sim X) \wedge \neq \backslash X$  X←B  
*Places between pairs of ones*
- 306  $\wedge \backslash X$  X←B  
*Turn off all ones after first zero*
- 307  $< \backslash X$  X←B  
*Turn off all ones after first one*
- 308  $\leq \backslash X$  X←B  
*Turn on all zeroes after first zero*
- 309  $\neq \backslash X$  X←B  
*Running parity*
- 310  $+\backslash X$  X←D  
*Cumulative sum*

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REDUCTION  $\omega/\omega t$ 

- 311  $(\uparrow/X)=\downarrow/X$  X←D1  
Test if all elements of vector X are equal
- 312  $(\uparrow/X)-\downarrow/X$  X←D1  
Size of range of elements of X
- 313  $-/\times\neq 0\ 1\Phi X$  X←D2  
Evaluating a two-row determinant
- 314  $-/\times/0\ 1\Theta X$  X←D2  
Evaluating a two-row determinant
- 315  $(\wedge/X)\vee\sim\vee/X$  X←B1  
Test if all elements of vector X are equal
- 316  $(\wedge/X)=\vee/X$  X←B1  
Test if all elements of vector X are equal
- 317  $\wedge/X\div\vee/X$  X←B1  
Test if all elements of vector X are equal
- 318  $(\times/((+/X+2)-0,X))\times.5$  X←D1; 3 ↔ pX  
Area of triangle with side lengths in X (Heron's formula)
- 319  $((+/(X-(+/X)\div pX)\times 2)\div pX)\times.5$  X←D1  
Standard deviation of X
- 320  $(+/(X-(+/X)\div pX)\times 2)\div pX$  X←D1  
Variance (dispersion) of X
- 321  $(+/(X-(+/X)\div pX)\times Y)\div pX$  X←D1  
Y:th moment of X
- 322  $\wedge/((1\uparrow X)\epsilon 10\downarrow A), X\epsilon A\leftarrow'0..9A..Z\Delta A..X\Delta'$  X←C1  
Test if X is a valid APL name
- 323  $Y\uparrow((\downarrow-/ .5\times Y, pX)p' '), X$  X←C1; Y←I0  
Centering text line X into a field of width Y
- 324  $\wedge/X=1\uparrow X$  X←A1  
Test if all elements of vector X are equal
- 325  $(+/X)\div^{-1}\uparrow 1, pX$  X←D2  
Average (mean value) of rows of matrix X
- 326  $(+\uparrow X)\div 1\uparrow(pX), 1$  X←D2  
Average (mean value) of columns of matrix X
- 327  $(^{-1}\Phi 1\uparrow(\vee/X\neq^{-1}\Theta X), 1)\uparrow X$  X←A2  
Removing duplicate rows from ordered matrix X

- 328  $\times /^{-1} \uparrow pX$  X←A  
Number of rows in array X (also of a vector)
- 329  $(\downarrow /X) \epsilon X$  X←I1  
Converting set of positive integers X into a mask
- 330  $X \downarrow /X$  X←D1  
Index of (first) maximum element of X
- 331  $\downarrow / \downarrow 0$   
Negative infinity; the smallest representable value
- 332  $(+ /, X) \div 1 \uparrow p, X$  X←D  
Arithmetic average (mean value), also for an empty array
- 333  $A[X] \Delta A[Y] \leftarrow 1 \Delta A \leftarrow (\downarrow /X, Y) p 0$  X←I1; Y←I1  
Quick membership ( $\epsilon$ ) for positive integers
- 334  $\downarrow /X, 0$  X←D1  
Positive maximum, at least zero (also for empty X)
- 335  $\downarrow /X$  X←D1  
Maximum of elements of X
- 336  $X \downarrow \downarrow /X$  X←D1  
Index of (first) minimum element of X
- 337  $\downarrow / \downarrow 0$   
Positive infinity; the largest representable value
- 338  $\downarrow /X \downarrow Y$  X←C1; Y←C1  
Index of first occurrence of elements of Y
- 339  $\downarrow /X$  X←D1  
Minimum of elements of X
- 340  $0 = (pX) \downarrow + /X$  X←B1  
Test if all elements of vector X are equal
- 341  $\wedge /X \downarrow 1 \Phi X$  X←B1  
Test if all elements of vector X are equal
- 342  $+ /A \times^{-1} * A \leftarrow 1 \Phi A \leftarrow 0, 1000 \ 500 \ 100 \ 50 \ 10 \ 5 \ 1 [ 'MDCLXVI' \downarrow X ]$  X←A  
Interpretation of roman numbers
- 343  $\wedge /X = 1 \Phi X$  X←A1  
Test if all elements of vector X are equal
- 344  $\wedge /X = 1 \Theta X$  X←A2  
Comparison of successive rows
- 345  $\wedge / (X \epsilon Y), Y \epsilon X$  X←A1; Y←A1  
Identity of two sets

- 346  $\wedge / (i_p X) \in X$  X ← I1  
Test if X is a permutation vector
- 347  $\neq / 0 \ 1 \in X$  X ← B1  
Test if all elements of vector X are equal
- 348  $\vee / Y \in X$  X ← A; Y ← A1  
Test if X and Y have elements in common
- 349  $\sim \wedge / X \in \sim X$  X ← B1  
Test if all elements of vector X are equal
- 350  $\wedge / , X \in 0 \ 1$  X ← A  
Test if X is boolean
- 351  $\wedge / Y \in X$  X ← A; Y ← A1  
Test if Y is a subset of X ( $Y \subset X$ )
- 352  $\neq / 0 \ 1 \in X$  X ← B1  
Test if all elements of vector X are equal
- 353  $\wedge / (X_1 X) = i_p X$  X ← A1  
Test if each element of X occurs only once
- 354  $\wedge / \square I O = X_1 X$  X ← A1  
Test if all elements of vector X are equal
- 355  $\sim \vee / X$  X ← B  
None, neither
- 356  $\vee / X$  X ← B  
Any, anyone
- 357  $\wedge / , X = Y$  X ← A; Y ← A;  $pX \leftrightarrow pY$   
Test if arrays of equal shape are identical
- 358  $\wedge / X = X[1]$  X ← A1  
Test if all elements of vector X are equal
- 359  $\wedge / ' ' = X$  X ← C2  
Blank rows
- 360  $\wedge / X$  X ← B  
All, both
- 361  $\neq / X$  X ← B  
Parity
- 362  $+ / X = , Y$  X ← A0; Y ← A  
Number of occurrences of scalar X in array Y
- 363  $(-X[2] - 1 \ 1 \times ((X[2] * 2) - x / 4, X[1 \ 3]) * .5) \div 2 \times X[1]$  X ← D1;  $3 \leftrightarrow pX$   
(Real) solution of quadratic equation with coefficients X

- 364  $(+/[Y]X) \div (\rho X)[Y]$  X←D; Y←I0  
Average (mean value) of elements of X along direction Y
- 365  $(+/X) \div \rho X$  X←D1  
Arithmetic average (mean value)
- 366  $\times / \rho X$  X←A  
Number of elements (also of a scalar)
- 367  $\div / X$  X←D  
Alternating product
- 368  $\times / X$  X←D1  
Product of elements of X
- 369  $- / X$  X←D  
Alternating sum
- 370  $+ / X$  X←B1  
Number of elements satisfying condition X
- 371  $+ / X$  X←A1  
Reshaping one-element vector X into a scalar
- 372  $+ \dagger X$  X←D2  
Column sum of a matrix
- 373  $+ / X$  X←D2  
Row sum of a matrix
- 374  $+ / X$  X←D1  
Sum of elements of X
- 
- TAKE ↑
- 375  $Y[1G;], [1]((1 \dagger \rho Y) \dagger X), [1](2 \dagger G) \dagger Y$  X←A1; Y←A2; G←I0  
Inserting vector X into matrix Y after row G
- 376  $(A \dagger X), [11](1 \dagger A \leftarrow (\rho X)[0, \rho Y]) \dagger Y$  X←A2; Y←A1  
Inserting vector Y to the end of matrix X
- 377  $Y \dagger X, Y \rho^{-1} \dagger X$  X←A1; Y←I0  
Filling X with last element of X to length Y
- 378  $X[Y;] \leftarrow (1 \dagger \rho X) \dagger \square$  X←C2; Y←I0  
Input of row Y of text matrix X
- 379  $(1 \dagger A) \dagger (A \wedge 1 \Phi A \leftarrow X = Y) / X$  X←A1; Y←A0  
Removing leading, multiple and trailing Y's
- 380  $X \leftarrow (\rho X) \rho A \Delta A[(A = 1 \dagger Y) / \rho A \leftarrow X] \leftarrow 1 \dagger Y$  X←A; Y←A1  
Changing elements in X with value Y[1] into Y[2]

- 381  $X > ((-ppX) \uparrow^{-1}) \downarrow 0, X$  X ← B  
First ones in groups of ones
- 382  $(G \uparrow Y), X, G \downarrow Y$  X ← A1; Y ← A1; G ← I0  
Inserting X into Y after index G
- 383  $X - ((-ppX) \uparrow^{-1}) \downarrow 0, X$  X ← D  
Pairwise differences of successive columns (inverse of +\)
- 384  $((-ppX) \uparrow 1) \downarrow X, 0$  X ← D  
Rightmost neighboring elements
- 385  $((-ppX) \uparrow^{-1}) \downarrow 0, X$  X ← D  
Leftmost neighboring elements
- 386  $(-pX) \uparrow (-Y) \downarrow X$  X ← A1; Y ← I0  
Shifting vector X right with Y without rotate
- 387  $(pX) \uparrow Y \downarrow X$  X ← A1; Y ← I0  
Shifting vector X left with Y without rotate
- 388  $(2 \uparrow Y) \downarrow X$  X ← A2; Y ← I0  
Drop of Y first rows from matrix X
- 389  $, \Phi(Ap2)p(2 \times A \leftarrow [2 \otimes X]) \uparrow 1, X$  X ← I0  
Playing order in a cup for X ranked players
- 390  $((1 \ 0 \times pY)[pX]) \uparrow X$  X ← A2; Y ← A2  
Lengthening matrix X to be compatible with Y
- 391  $((0 \ 1 \times pY)[pX]) \uparrow X$  X ← A2; Y ← A2  
Widening matrix X to be compatible with Y
- 392  $(1 \uparrow^{-2} \uparrow pX)pX$  X ← A; 2 ≥ ppX  
Reshaping non-empty lower-rank array X into a matrix
- 393  $(-1.5 \times Y + pX) \uparrow X$  X ← C1; Y ← I0  
Centering text line X into a field of width Y
- 394  $(X \downarrow pY) \uparrow Y$  X ← I; Y ← A  
Take of at most X elements from Y
- 395  $(-1 \uparrow pY) \downarrow (Y) \downarrow X$  Y ← C2; X ← C  
Alphabetizing X; equal alphabets in same column of Y
- 396  $(\sim(1 \uparrow^{-1} \uparrow pX) \epsilon Y) / X$  X ← A; Y ← I1  
Removing columns Y from array X
- 397  $(-1 \uparrow (' \neq X) / 1pX)pX$  X ← C1  
Removing trailing blanks
- 398  $(1 - 1 \uparrow^{-1} \uparrow pX) \Phi X$  X ← A2  
Aligning columns of matrix X to diagonals

- 399  $(-1+1-1+pX)\Phi X$  X←A2  
*Aligning diagonals of matrix X to columns*
- 400  $0\epsilon 1\uparrow 0pX$  X←A  
*Test if numeric*
- 401  $(-1+X1'')\uparrow X$  X←C1  
*First word in X*
- 402  $(-2\uparrow 1\ 1,pX)pX$  X←A; 2≥ppX  
*Reshaping non-empty lower-rank array X into a matrix*
- 403  $1\uparrow \square, X$  X←C0  
*Giving a character default value for input*
- 404  $(X\times Y)p(-Y)\uparrow 1$  X←I0; Y←I0  
*Ending points for X fields of width Y*
- 405  $(X\times Y)pY\uparrow 1$  X←I0; Y←I0  
*Starting points for X fields of width Y*
- 406  $X+(-pX)\uparrow Y$  X←D; Y←D0  
*Adding scalar Y to last element of X*
- 407  $Y\uparrow Xp1$  X←I0; Y←I0  
*Vector of length Y with X ones on the left, the rest zeroes*
- 408  $1\ 80p80\uparrow X$  X←A1  
*Forming first row of a matrix to be expanded*
- 409  $1\uparrow 0pX$  X←A  
*Zero or space depending on the type of X (fill element)*
- 410  $-1\uparrow pX$  X←A2  
*Number of columns in matrix X*
- 411  $1\uparrow pX$  X←A2  
*Number of rows in matrix X*
- 412  $(-Y)\uparrow X$  Y←I0; X←C1  
*Transferring text X to right edge of field of width Y*
- *DROP ↓*
- 413  $(1\uparrow A)-1\uparrow A+(A,1)/11+pA+1,(1\uparrow X)\neq -1\uparrow X$  X←A1  
*Lengths of subvectors with equal elements*
- 414  $G-1\uparrow 0,G+(\sim\square I0)+(((1\uparrow X)\neq -1\uparrow X),1)/1pX$  X←A1; G←I1  
*Field lengths of vector X; G ↔ ending indices*
- 415  $(A>0)/A+(1\uparrow A)-1+1\uparrow A+(\sim A)/1pA+0,X,0$  X←B1  
*Lengths of groups of ones in X*

- 416  $((A\downarrow 1)-\square IO)\downarrow(\square IO-(\Phi A\leftarrow\sim X\in Y)\downarrow 1)\downarrow X$  X←A1; Y←A  
Removing elements Y from beginning and end of vector X
- 417  $((1\downarrow X)\neq^{-1}\downarrow X),1$  X←A1  
Ending points of equal groups
- 418  $1,(1\downarrow X)\neq^{-1}\downarrow X$  X←A1  
Starting points of equal groups
- 419  $(1\downarrow X)\div^{-1}\downarrow X$  X←D1  
Pairwise ratios of successive elements of vector X
- 420  $(1\downarrow X)-^{-1}\downarrow X$  X←D1  
Pairwise differences of successive elements of vector X
- 421  $(Y\wedge X)\vee(Y\vee X)\backslash A>^{-1}\downarrow 0,A\leftarrow(Y\vee X)/Y$  X←B1; Y←B1  
First ones of subvectors of Y indicated by X (<\)
- 422  $(^{-1}\Phi 1\downarrow(X\neq^{-1}\Phi X),1)/X$  X←A1  
Removing duplicates from an ordered vector
- 423  $A-^{-1}\downarrow 0,A\leftarrow(1\Phi X)/\downarrow pX$  X←B1  
Changing starting indicators of subvectors to lengths
- 424  $(A\vee 1\downarrow 1\Phi 1,A\leftarrow' ' \neq X)/X$  X←C1  
Removing multiple blanks
- 425  $(pX)pA \Delta A[(A=1pY)/\downarrow pA\leftarrow,X]\leftarrow 1\downarrow Y$  X←A; Y←A1; 2 ↔ pY  
Replacing all values Y[1] by Y[2] in X
- 426  $(A\vee^{-1}\downarrow 1,A\leftarrow X\neq Y)/X$  X←A1; Y←A0  
Removing duplicate Y's from vector X
- 427  $(\square IO-(\sim\Phi X\in Y)\downarrow 1)\downarrow X$  X←A1; Y←A  
Removing elements Y from end of vector X
- 428  $(1-(\Phi' ' \neq X)\downarrow 1)\downarrow X$  X←C1  
Removing trailing blanks
- 429  $0^{-1}\downarrow(-\downarrow pX)\Phi((2ppX)p0),X$  X←D1  
Diagonal matrix with elements of X
- 430  $^{-1}\downarrow X\times\Phi^{-1}\downarrow pX$  X←D1  
Derivate of polynomial X
- 431  $(^{-1}\downarrow X\neq 1\Phi X),1$  X←A1  
Test if an element differs from the next one
- 432  $1,1\downarrow X\neq^{-1}\Phi X$  X←A1  
Test if an element differs from the previous one
- 433  $1\Phi^{-1}\downarrow Y,X$  X←A1; Y←A0  
Replacing last element of X with Y

- 434  $\neg 1 \downarrow X, Y$  X←A1; Y←A0  
Replacing first element of X with Y
- 435  $((\neg X \epsilon Y) \downarrow 1) - \square 10 \downarrow X$  X←A1; Y←A  
Removing elements Y from beginning of vector X
- 436  $X - (-Y \downarrow p X) \downarrow 0, [Y] X$  X←D; Y←I0  
Differences of successive elements of X along direction Y
- 437  $(\neg 1 + (X = '0') \downarrow 0) \downarrow X$  X←A1  
Removing leading zeroes
- 438  $Y + (Y \downarrow X) \downarrow 1$  G←I0; X←B1  
Index of first one after index Y in X
- 439  $X > 1 \downarrow X, 0$  X←B1  
Last ones in groups of ones
- 440  $X > \neg 1 \downarrow 0, X$  X←B1  
First ones in groups of ones
- 441  $1 \downarrow ', ', X$  X←C2  
List of names in X (one per row)
- 442  $X - \neg 1 \downarrow 0, X$  X←D1  
Restoring argument of cumulative sum (inverse of +\)
- 443  $(0, Y) \downarrow X$  X←A2; Y←I0  
Drop of Y first columns from matrix X
- 444  $(Y, 0) \downarrow X$  X←A2; Y←I0  
Drop of Y first rows from matrix X
- 445  $1 \downarrow p X$  X←A2  
Number of columns in matrix X
- 446  $\neg 1 \downarrow p X$  X←A2  
Number of rows in matrix X
- 447  $(Y \times G) \downarrow X$  X←A; Y←I1; G←B1  
Conditional drop of Y elements from array X
- 448  $(-Y) \downarrow X$  X←A1; Y←B0  
Conditional drop of last element of X
- 
- CEILING / MAXIMUM I
- 449  $Y[1] [Y[2]] X$  X←D; Y←D1  
Limiting X between Y[1] and Y[2], inclusive
- 
- FLOOR / MINIMUM I

- 450  $\lfloor 10^{\otimes} \rfloor 1 - 3 \times \div 3$   
Arithmetic precision of the system (in decimals)
- 451  $X + (G \times Y - X) \times (\lfloor 1 + \lfloor (Y - X) \div G \rfloor - \square 10$   $X \leftarrow D0$ ;  $Y \leftarrow D0$ ;  $G \leftarrow D0$   
Arithmetic progression from X to Y with step G
- 452  $1 + (X < 0) + \lfloor 10^{\otimes} \rfloor X + 0 = X$   $X \leftarrow I$   
Number of digitpositions in integers in X
- 453  $\lfloor X + 1 \rfloor \leq 2 \lfloor X$   $X \leftarrow D$   
Rounding to nearest even integer
- 454  $\lfloor X + .5 \times .5 \neq 2 \rfloor X$   $X \leftarrow D$   
Rounding, to nearest even integer for .5 = 1  $\lfloor \rfloor X$
- 455  $1 + \lfloor 10^{\otimes} (X = 0) + X \times 1 \rfloor - 10 \lfloor 1 + X < 0 \rfloor$   $X \leftarrow I$   
Number of digit positions in integers in X
- 456  $1 + \lfloor 10^{\otimes} X + 0 = X$   $X \leftarrow I$   
Number of digits in positive integers in X
- 457  $X = \lfloor X$   $X \leftarrow D$   
Test if integer
- 458  $(X, G) \lfloor (1 + \rho X) \rfloor Y \rfloor$   $X \leftarrow A1$ ;  $Y \leftarrow I$ ;  $G \leftarrow A0$   
Limiting indices and giving a default value G
- 459  $\lfloor X + 1000$   $X \leftarrow I$   
First part of numeric code ABBB
- 460  $(10 * -X) \times \lfloor 0.5 + Y \times 10 * X$   $X \leftarrow I$ ;  $Y \leftarrow D$   
Rounding to X decimals
- 461  $0.01 \times \lfloor 0.5 + 100 * X$   $X \leftarrow D$   
Rounding to nearest hundredth
- 462  $\lfloor 0.5 + X$   $X \leftarrow D$   
Rounding to nearest integer
- MAGNITUDE / RESIDUE |
- 463  $(0 = 400 \lfloor X \rfloor) \vee (0 \neq 100 \lfloor X \rfloor) \wedge 0 = 4 \lfloor X$   $X \leftarrow I$   
Test if X is a leap year
- 464  $'\_',[1](' \lfloor ', X, ' \rfloor '), [1]' \rfloor '$   $X \leftarrow C2$   
Framing
- 465  $1 \lfloor \rfloor X$   $X \leftarrow D$   
Magnitude of fractional part
- 466  $(0 \neq Y \lfloor \rho X \rfloor) / X$   $X \leftarrow A1$ ;  $Y \leftarrow I0$   
Removing every Y:th element of X

- 467  $(0=Y|_1pX)/X$  X←A1; Y←I0  
Taking every Y:th element of X
- 468  $(0=A|X)/A←_1X$  X←I0  
Divisors of X
- 469  $(2|_1pX)/X$  X←A1  
Removing every second element of X
- 470  $(0=Y|X)/X$  X←D1; Y←D0 or D1  
Elements of X divisible by Y
- 471  $\square I0+(pX)|Y+(Y\Phi X)|_1G$  X←A1; Y←I0; G←A  
Index of first occurrence of G in X (circularly) after Y
- 472  $(1+pY)|Y|_1X$  Y←A1; X←A  
Changing index of an unfound element to zero
- 473  $\sim 2|X$  X←I  
Test if even
- 474  $X \times Y \leq |X$  X←D; Y←D  
Rounding to zero values of X close to zero
- 475  $(\times X) \times Y + |X$  X←D; Y←D  
Increasing absolute value without change of sign
- 476  $(\times X)|X$  X←D  
Fractional part with sign
- 477  $X \times |X$  X←D  
Square of elements of X without change of sign
- 478  $1|X$  X←D  
Fractional part
- 479  $1000|X$  X←I  
Last part of numeric code ABBB

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EXPAND \

- 480  $A \setminus (A \leftarrow \sim X \epsilon Y) / X$  X←A0; Y←A1  
Replacing elements of X in set Y by blanks / zeroes
- 481  $A \setminus (A \leftarrow X \epsilon Y) / X$  X←A1; Y←A  
Replacing elements of X not in set Y by blanks / zeroes
- 482  $A \Delta A[(\sim G)/_1pG] + Y \Delta A \leftarrow G \setminus X$  X←A1; Y←A1; G←B1  
Merging X and Y under control of G (mesh)
- 483  $Y \setminus Y / X$  X←A; Y←B1  
Replacing elements of X not fulfilling Y by blanks / zeroes

- 484  $\Phi\alpha\backslash\Phi X$  X←A  
Scan from end with  $\alpha$
- 485  $(\sim(1(pY)+1ppX)\epsilon Y+1pY)\backslash X$  X←A2; Y←I1  
Adding an empty row into X after rows Y
- 486  $0\epsilon 0\backslash 0pX$  X←A1  
Test if numeric
- 487  $((Y+1)\neq 11+1ppX)\backslash X$  X←A2; Y←I0  
Adding an empty row into X after row Y
- 488  $X, [\square IO-.1](' ' \neq X)\backslash '-'$  X←C1  
Underlining words
- 489  $(pY)p(,Y)\backslash X$  X←A1; Y←B2  
Using boolean matrix Y in expanding X
- 490  $((2 \times pX)p1\ 0)\backslash X$  X←C1  
Spacing out text
- 
- COMPRESS /
- 491  $(X/Y) \geq A/1\Phi A + (Y \vee X)/X$  X←B1; Y←B1  
Or-reduction ( $\vee$ ) of subvectors of Y indicated by X
- 492  $(X/Y) \wedge A/1\Phi A + (Y \leq X)/X$  X←B1; Y←B1  
And-reduction ( $\wedge$ ) of subvectors of Y indicated by X
- 493  $(G/X), (\sim G)/Y$  X←C1; Y←C1; G←B0  
Choosing a string according to boolean value G
- 494  $(A \vee 1\Phi A \leftarrow X \neq ' ')/X$  X←C1  
(Cyclic) compression of successive blanks
- 495  $(X \epsilon Y)/1pX$  X←A1; Y←A  
Indices of all occurrences of elements of Y in X
- 496  $(\sim X \epsilon '.,,:;?'')/X$  X←A1  
Removing punctuation characters
- 497  $Y, (\sim X \epsilon Y)/X$  X←A1; Y←A1  
Union of sets, u
- 498  $(\sim X \epsilon Y)/X$  X←A1; Y←A  
Elements of X not in Y (difference of sets)
- 499  $(X[;1] \epsilon Y) \neq X$  X←A2; Y←A1  
Rows of non-empty matrix X starting with a character in Y
- 500  $(X \epsilon Y)/X$  X←A1; Y←A  
Intersection of sets, n

- 501  $((X \setminus X) = \setminus p X) / X$  X ← A1  
Removing duplicate elements (nub)
- 502  $((p X) * Y \neq \setminus p p X) p \alpha / [Y] X$  Y ← I0; X ← A  
Reduction in dimension Y, rank unchanged
- 503  $(Y = X) / \setminus p X$  X ← A1; Y ← A0  
Indices of all occurrences of Y in X
- 504  $Y[X / \setminus p Y] \leftarrow G$  Y ← A1 X ← B1 G ← A0  
Replacing elements of Y satisfying X with G
- 505  $A / \setminus 9999 \Delta A[X] \leftarrow 1 \Delta A \leftarrow 9999 p 0$  X ← I1  
Removing duplicates from positive integers
- 506  $X / \setminus p X$  X ← B1  
Indices of ones in logical vector X
- 507  $(, X, [1.5] 1) / , X, [1.5] \sim X$  X ← B1  
Vector to expand a new element after each one in X
- 508  $((\sim X) / 'IN'), 'CORRECT'$  X ← B0  
Conditional in text
- 509  $(X \neq Y) / X$  X ← A1; Y ← A0  
Removing elements Y from vector X
- 510  $(' ' \neq X) / X$  X ← A1  
Removing blanks
- 511  $\alpha / , X$  X ← D  
Reduction with  $\alpha$  without respect to shape
- 512  $Y / X$  X ← A; Y ← B1  
Selecting elements of X satisfying condition Y
- 513  $0 \nmid X$  X ← A2  
Empty matrix
- 
- TRANSPOSE  $\Phi$
- 514  $\Phi F \Phi X$  X ← A1; Y ← I0  
Applying to columns function F defined on rows
- 515  $((\Phi A) \times 1, Y) p 2 \ 1 \ 3 \Phi (1 \Phi Y, A + (p X) \div 1, Y) p X$  X ← A2; G ← I0  
"Transpose" of matrix X with column fields of width Y
- 516  $X \times \Phi (\Phi p X) p Y$  X ← D2; Y ← D1  
Multiplication of each column of matrix X by vector Y
- 517  $\Phi (\Phi p Y) p X$  X ← A1; Y ← A2  
Matrix with shape of Y and X as its columns

- 518  $(Y \oplus 1 \ 2) \oplus X$  X←A2; Y←B0  
Transpose matrix X on condition Y
- 519  $\sim 0 \in X = - \oplus X$  X←D2  
Test for antisymmetry of square matrix X
- 520  $\sim 0 \in X = \oplus X$  X←A2  
Test for symmetry of square matrix X
- 521  $\oplus(X, \rho Y) \rho Y$  X←I0; Y←D1  
Matrix with X columns Y
- 522  $1 \ 1 \oplus X[Y[1;]; Y[2;]]$  X←A2; Y←I2  
Retrieving scattered elements Y from matrix X
- 523  $X[Y] \oplus G$  X←I1; Y←I1  
Successive transposes of G (X after Y;  $X \oplus Y \oplus G$ )
- 524  $40 \ 120 \rho 2 \ 1 \ 3 \oplus 10 \ 40 \ 12 \rho X$  X←C2  
Dividing a 400×12 character matrix into one page
- 525  $(1 * \rho X) \oplus X$  X←A  
Main diagonal of array X
- 526  $1 \ 1 \oplus X$  X←A2  
Diagonal elements of matrix X
- 527  $1 \ 3 \ 2 \oplus X$  X←A3  
Transpose of planes of a rank three array
- REVERSE / ROTATE  $\oplus \ominus$
- 528  $((1 \oplus X) \times^{-1} \oplus Y) - (-1 \oplus X) \times 1 \oplus Y$  X←D; Y←D  
Vector (cross) product of vectors
- 529  $1 \oplus (1 \rho X) \in Y$  X←A1; Y←I1  
Ending points for X in indices pointed by Y
- 530  $(-1 \ 1 [2 \times \square IO] + \rho X) - (\oplus X) \backslash Y$  X←A1; Y←A0  
Index of last element of Y in X
- 531  $(1 + \rho X) - (\oplus X) \backslash Y$  X←A1; Y←A  
Index of last occurrence
- 532  $(\oplus X) \backslash Y$  X←A1; Y←A  
Index of last occurrence, counted from the rear
- 533  $\ominus, \oplus[\square IO + Y](1, \rho X) \rho X$  X←A1; Y←B0  
Reverse vector X on condition Y
- 534  $(\oplus 1, \rho X) \rho X$  X←A1  
Reshaping vector X into a one-column matrix

535  $(\Phi 1, \dots)$  ... $\leftarrow$ EXPRESSION  
Avoiding parentheses with help of reversal

536  $1\Phi X$   $X \leftarrow A$   
Rightmost neighboring elements cyclically

537  $\sim 1\Phi X$   $X \leftarrow A$   
Leftmost neighboring elements cyclically

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MEMBER OF  $\epsilon$

538  $\sim (1(pY) + pX) \epsilon Y + 1pY$   $X \leftarrow A1; Y \leftarrow I1$   
Expansion vector with zero after indices Y

539  $(\sim (1Y) \epsilon X)$   $X \leftarrow I; Y \leftarrow I0$   
Boolean vector of length Y with zeroes in locations X

540  $(1pX) \epsilon Y$   $X \leftarrow A1; Y \leftarrow I1$   
Starting points for X in indices pointed by Y

541  $(X \epsilon Y) \times Y 1X$   $X \leftarrow A; Y \leftarrow A1$   
Changing index of an unfound element to zero (not effective)

542  $(Y \leftarrow \square) \epsilon 1X$   $X \leftarrow A$   
Check for input in range 1..X

543  $(1Y) \epsilon X$   $X \leftarrow I; Y \leftarrow I0$   
Boolean vector of length Y with ones in locations X

544  $\sim 0 \epsilon X = Y$   $X \leftarrow A; Y \leftarrow A$   
Test if arrays are identical

545  $Y \times \sim Y \epsilon X$   $Y \leftarrow D; X \leftarrow D$   
Zeroing elements of Y depending on their values

546  $1 \epsilon p, X$   $X \leftarrow A$   
Test if single or scalar

547  $1 \epsilon ppX$   $X \leftarrow A$   
Test if vector

548  $0 \epsilon pX$   $X \leftarrow A$   
Test if X is an empty array

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INDEX GENERATOR / INDEX OF  $\iota$

549  $(G 1X) < G 1Y$   $X \leftarrow A; Y \leftarrow A$   
Alphabetical comparison with alphabets G

550  $X \iota 1pX$   $X \leftarrow I1$   
Inverting a permutation

- 551  $(Y \neq X) \wedge 1$  X←A1; Y←A1  
Index of first differing element in vectors X and Y
- 552  $(\square IO + pY) = Y \wedge X$  X←A; Y←A1  
Which elements of X are not in set Y (difference of sets)
- 553  $A \Delta A[X] \leftarrow A \Delta A \leftarrow 1pX$  X←I1  
Inverting a permutation
- 554  $G[Y \wedge X; ]$  X←D; Y←D1; G←G2  
Changing numeric code X into corresponding name in Y
- 555  $1ppX$  X←A  
All axes of array X
- 556  $1pX$  X←A1  
All indices of vector X
- 557  $X + G \times (1Y) - \square IO$  X←D0; Y←D0; G←D0  
Arithmetic progression of Y numbers from X with step G
- 558  $(X - \square IO) \wedge 11 + Y - X$  X←I0; Y←I0  
Consecutive integers from X to Y (arithmetic progression)
- 559  $X \wedge 1$  X←B1  
Index of first satisfied condition in X
- 560  $11$   
Index origin ( $\square IO$ ) as a vector
- 561  $\square AV \wedge X$  X←A  
Converting characters into numeric codes
- 562  $X \wedge Y$  X←A1; Y←A  
Index of key Y in key vector X
- 563  $10$   
Empty numeric vector

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LOGICAL  $\sim \vee \wedge \rightarrow \leftarrow$ 

- 564  $(Y[1] < X) \wedge X < Y[2]$  X←D; Y←D1  
Test if X is within range ( Y[1], Y[2] )
- 565  $(Y[1] \leq X) \wedge (X \leq Y[2])$  X←D; Y←D1; 2←pY  
Test if X is within range [ Y[1], Y[2] ]
- 566  $0 \wedge X$  X←B  
Zeroing all boolean values
- 567  $(X \times G) + Y \times \sim G$  X←D; Y←D; G←B  
Selection between X and Y depending on condition G

- 568  $(\sim \square IO)+X$   $X \leftarrow I$   
Changing an index origin dependent result to be as  $\square IO=1$
- 569  $Y \star \sim X$   $Y \leftarrow D; X \leftarrow B$   
Conditional change of elements of  $Y$  to one according to  $X$
- 
- COMPARISON  $< \leq = \geq > \neq$
- 570  $X \leq Y$   $X \leftarrow B; Y \leftarrow B$   
 $X$  implies  $Y$
- 571  $X > Y$   $X \leftarrow B; Y \leftarrow B$   
 $X$  but not  $Y$
- 572  $(0 \neq X) \times Y \div X + 0 = X$   $X \leftarrow D; Y \leftarrow D$   
Avoiding division by zero error (gets value zero)
- 573  $X \neq Y$   $X \leftarrow B; Y \leftarrow B$   
Exclusive or
- 574  $X + Y \times X = 0$   $X \leftarrow D; Y \leftarrow D$   
Converting zeroes to  $Y$
- 575  $Y = X$   $X \leftarrow I; Y \leftarrow I$   
Kronecker delta of  $X$  and  $Y$  (element of identity matrix)
- 
- RAVEL / CATENATE ,
- 576  $, (((pX), Y) pG), X$   $X \leftarrow A1; Y \leftarrow IO; G \leftarrow A0$   
Catenating  $Y$  elements  $G$  before every element of  $X$
- 577  $, X, (((pX), Y) pG)$   $X \leftarrow A1; Y \leftarrow IO; G \leftarrow A$   
Catenating  $Y$  elements  $G$  after every element of  $X$
- 578  $, Y, [\square IO+.5]X$   $X \leftarrow A1; Y \leftarrow A1$   
Merging vectors  $X$  and  $Y$  alternately
- 579  $X, \square TC[2], Y$   $X \leftarrow A1; Y \leftarrow A1$   
Separating variable length lines
- 580  $, X, [1.1]' '$   $X \leftarrow C1$   
Spacing out text
- 581  $, X, [1.1]Y$   $X \leftarrow A1; Y \leftarrow A0$   
Inserting  $Y$  after each element of  $X$
- 582  $(X, X) p1, X p0$   $X \leftarrow IO$   
 $X \times X$  identity matrix
- 583  $X, [.5+ppX]-X$   $X \leftarrow D$   
Array and its negative ('plus minus')

- 584  $X \leftarrow (pX) pA \Delta A[G] \leftarrow Y \Delta A \leftarrow X$   $X \leftarrow A$ ;  $Y \leftarrow A$ ;  $G \leftarrow I$   
Temporary ravel of  $X$  for indexing with  $G$
- 585  $X \leftarrow ApX \Delta X[G] \leftarrow Y \Delta X \leftarrow X \Delta A \leftarrow pX$   $X \leftarrow A$ ;  $Y \leftarrow A$ ;  $G \leftarrow I$   
Temporary ravel of  $X$  for indexing with  $G$
- 586  $X, [\square IO-.1]' \text{---}$   $X \leftarrow C1$   
Underlining a string
- 587  $X[:,1]$   $X \leftarrow A2$   
First column as a matrix
- 588  $X, [1.1]Y$   $X \leftarrow A1$ ;  $Y \leftarrow A1$   
Forming a two-row matrix
- 589  $X, [1.1]Y$   $X \leftarrow A1$ ;  $Y \leftarrow A1$   
Forming a two-column matrix
- 590  $((((pX) - pY)p1), pY)pY$   $X \leftarrow A$ ;  $Y \leftarrow A$   
Increasing rank of  $Y$  to rank of  $X$
- 591  $((0.5 \times pX), 2)pX$   $X \leftarrow A1$   
Reshaping vector  $X$  into a two-column matrix
- 592  $(pX)p \dots, X$   $X \leftarrow A$ ;  $\dots \leftarrow \text{EXPRESSION}$   
Handling array  $X$  temporarily as a vector
- 593  $(Y, pX)pX$   $X \leftarrow A1$ ;  $Y \leftarrow IO$   
Forming a  $Y$ -row matrix with all rows alike ( $X$ )
- 594  $((pX), 1)pX$   $X \leftarrow A1$   
Reshaping vector  $X$  into a one-column matrix
- 595  $(1, pX)pX$   $X \leftarrow A1$   
Reshaping vector  $X$  into a one-row matrix
- 596  $p, X$   $X \leftarrow A$   
Number of elements (also of a scalar)
- 597  $Y, 0pX$   $X \leftarrow A$ ;  $Y \leftarrow A1$   
Joining sentences
- 598  $X \leftarrow 0 \ 2 \ 1 \ 2 \ 5 \ 8 \ 0 \ 4 \ 5, \square$   $X \leftarrow D$   
Entering from terminal data exceeding input (printing) width
- 
- AXIS / INDEXING I
- 599  $(pX)[ppX]$   $X \leftarrow A$   
Number of columns in array  $X$
- 600  $(pX)[2]$   $X \leftarrow A2$   
Number of columns in matrix  $X$

601	(pX)[1] <i>Number of rows in matrix X</i>	X←A2
602	Y[2+X] <i>Choosing according to signum</i>	X←D; Y←A1
603	Y×1 <sup>-1</sup> [1+X] <i>Conditional elementwise change of sign</i>	Y←D; X←B
604	X[2×□IO] <i>Selection depending on index origin</i>	X←A1
605	' *'[□IO+X] <i>Indexing with boolean value X (plotting a curve)</i>	X←B
606	X[□IO+Y] <i>Indexing independent of index origin</i>	X←A1; Y←I
607	X[;1] <i>First column as a vector</i>	X←A2
608	X[]←0 <i>Zeroing a vector (without change of size)</i>	X←D1
609	X[1] <i>Selection depending on index origin</i>	X←A1
---	SHAPE / RESHAPE p	
610	(Y×pX)pX <i>Duplicating vector X Y times</i>	X←A1; Y←IO
611	X×(pX)pY <i>Multiplication of each row of X by vector Y</i>	X←D; Y←D1
612	ppX <i>Rank of array X</i>	X←A
613	1ppX <i>Number of rows in matrix X</i>	X←A2
614	(pY)pX <i>Array with shape of Y and X as its rows</i>	X←A1; Y←A
615	1pX <i>Corner element of a (non-empty) array</i>	X←A
616	' 'pX <i>Reshaping X into a scalar</i>	X←A
617	0pX← <i>Output of an empty line</i>	X←A

- 618 0 80p0  
*Forming an initially empty array to be expanded*
- 
- ARITHMETIC + - \* ÷
- 619 1÷2÷3÷4÷5÷6 ...  
*Continued fraction*
- 620  $Y \div X$   $X \leftarrow D$ ;  $Y \leftarrow D$   
*Force 0÷0 into DOMAIN ERROR in division*
- 621 1  $^{-1} \times X$   $X \leftarrow D0$   
*Number and its negative ('plus minus')*
- 622  $Y \times X$   $X \leftarrow D$ ;  $Y \leftarrow B$   
*Selecting elements satisfying condition Y, zeroing others*
- 623  $X \times ^{-1} \times Y$   $X \leftarrow D$ ;  $Y \leftarrow B$ ;  $pX \leftrightarrow pY$   
*Conditional elementwise change of sign*
- 624 0×X  $X \leftarrow D$   
*Zero array of shape and size of X*
- 625  $\square IO - X$   $X \leftarrow I$   
*Changing an index origin dependent result to be as  $\square IO = 0$*
- 626  $(\square IO - 1) \times X$   $X \leftarrow I$   
*Changing an index origin dependent argument to act as  $\square IO = 1$*
- 627 +X←  $X \leftarrow D$   
*Output of assigned numeric value*
- 628  $\square IO + X$   $X \leftarrow I$   
*Changing an index origin dependent argument to act as  $\square IO = 0$*
- 
- MISCELLANEOUS
- 629 \*
- Syntax error to stop execution*
- 630  $\square \leftarrow X \leftarrow$   $X \leftarrow A$   
*Output of assigned value*
- 631  $\square LX \leftarrow \square$   
*Setting latent expression*

# SYNONYM LIST

## Adding X to each column of Y

193 1 1 2QX..+Y  
192 1 2 1QY..+X

## Adding X to each row of Y

190 2 1 2QX..+Y  
189 1 2 2QY..+X

## Arithmetic average (mean value)

365 (+/X)÷pX  
332 (+/,X)÷1[p,X

## Ascending cardinal numbers (ranking)

1 L.5×(ΔΔX)+ΦΔΔΦX  
13 ΔΔX

## Centering text

323 Y+((l-/.5×Y,pX)p' '),X  
393 (-l.5×Y+pX)↑X  
269 (-l0.5×+/^\' '=ΦX)ΦX  
248 (A-l0.5×(A++/^ΦA)++/^A<' '=ΦX)ΦX

## Changing index of an unfound element to zero

472 (1+pY)|Y,X  
541 (XεY)×Y,X

## Conditional elementwise change of sign

603 Y×1 -1[1+X]  
623 X×-1×Y

## Diagonal elements of matrix X

526 1 1QX  
525 (1×pX)QX

*Drop of Y first rows from matrix X*

444  $(Y,0) \downarrow X$   
 388  $(2 \uparrow Y) \downarrow X$

*Evaluating a two-row determinant*

314  $- / \times / 0 \ 1 \Theta X$   
 313  $- / \times / 0 \ 1 \Phi X$

*Expansion vector with zero after indices Y*

27  $(pX) \geq \Delta(1pX), Y$   
 538  $\sim(1(pY) + pX) \in Y + 1pY$

*First ones in groups of ones*

381  $X > ((-ppX) \uparrow^{-1}) \downarrow 0, X$   
 440  $X >^{-1} \downarrow 0, X$

*Giving a default value for input*

97  $1p(\pm \square, ', 10'), X$   
 403  $1 \uparrow \square, X$

*Index of (first) maximum element of X*

23  $^{-1} \uparrow \Delta X$   
 330  $X \uparrow / X$

*Index of (first) minimum element of X*

22  $1 \uparrow \Delta X$   
 336  $X \downarrow / X$

*Indices of ones in logical vector X*

41  $(+/X) \uparrow \Psi X$   
 280  $(+ \setminus X) \uparrow \uparrow + / X$   
 506  $X / 1pX$

*Inverting a permutation*

37  $\Delta X$   
 553  $A \Delta A[X] + A \Delta A + 1pX$   
 550  $X \uparrow 1pX$

Jul. 13, 1982

*Locations of texts between and including quotes*

287  $A \wedge^{-1} \downarrow 0, A \downarrow 2 \mid + \backslash X = ''''$   
 293  $A \wedge^{-1} \downarrow 0, A \downarrow \neq \backslash X = ''''$

*Locations of texts between quotes*

288  $A \wedge^{-1} \downarrow 0, A \downarrow 2 \mid + \backslash X = ''''$   
 294  $A \wedge^{-1} \downarrow 0, A \downarrow \neq \backslash X = ''''$

*Merging (mesh)*

482  $A \Delta A[(\sim G)/\downarrow pG] \leftarrow Y \Delta A \leftarrow G \backslash X$   
 12  $(X, Y)[\Delta \Delta G]$   
 16  $(Y, X)[\Delta \nabla G]$   
 31  $A \Delta A[\Delta G] \leftarrow A \leftarrow Y, X$   
 11  $(Y, X, Z, \dots)[\Delta \Delta G]$

*Number and its negative ('plus minus')*

621  $1^{-1} \times X$   
 583  $X, [.5 + p p X] - X$   
 204  $X \cdot \cdot \times 1^{-1}$

*Number of columns in matrix X*

600  $(pX)[2]$   
 410  $^{-1} \uparrow pX$   
 445  $1 \uparrow pX$   
 599  $(pX)[p p X]$

*Number of elements (also of a scalar)*

366  $\times / pX$   
 596  $p, X$

*Number of occurrences of scalar X in array Y*

236  $X + . = , Y$   
 362  $+ / X = , Y$

*Number of rows in matrix X*

601  $(pX)[1]$   
 411  $1 \uparrow pX$

```
613 1ppX
446 -1+pX
```

#### Occurrence(s) of string X in string Y

```
178 (A/(-1+ipX)OXO.=Y)11
147 (Y[AO.+1+ipX]A.=X)/A+(A=1+X)/ipA+(1-pX)+Y
219 ((-A)+XA.=(A,1+pY)pY)/i(pY)+1-A+pX
```

#### Output of assigned value

```
630 □←X←
627 +X←
```

#### Removing duplicate elements

```
501 ((X1X)=ipX)/X
154 (1 1Q<\XO.=X)/X
505 A/i9999 Δ A[X]+1 Δ A←9999p0
422 (-1Φ1+(X≠-1ΦX),1)/X
```

#### Removing duplicate rows

```
70 ((A1A)=ipA+21XA.=OX)+X
208 (1 1Q<\XA.=OX)+X
327 (-1Φ1+(v/X≠-1OX),1)+X
206 ((A1A)=ipA+□IO++f^Xv.≠OX)+X
```

#### Removing leading blanks

```
267 (+/\\' '=X)+X
299 (v\' '≠X)/X
```

#### Removing trailing blanks

```
298 (Φv\Φ' '≠X)/X
73 (1-(\' '=X)11)+X
397 (-1+(\' '≠X)/ipX)pX
428 (1-(Φ' '≠X)11)+X
266 (-+/\\' '=OX)+X
```

#### Removing trailing blank columns

```
272 (Φv\Φv+\' '≠X)/X
209 (Φv\Φ' 'v.≠X)/X
```

*Replicate Y[i] X[i] times (for all i)*

```
250 Y[+\(i+/X)ε-1↓1++\0,X]
251 ((X≠0)/Y)[+\-1Φ(i+/X)ε+\X]
253 Y[□IO++\ (i+/X)ε□IO++\X]
```

*Representations of current date*

```
107 A Δ A[( ' '=A)/iρA]← '/' Δ A←⌈100|1Φ3↑□TS
65 A Δ A[5 8]← '-' Δ A←⌈1000↑3↑□TS
104 A Δ A[( ' '=A)/iρA]← '.' Δ A←⌈Φ3↑□TS
72 100↑100|3↑□TS
```

*Representations of current time*

```
64 A Δ A[3 6]← ':' Δ A←⌈1000↑3↑3↓□TS
105 (, (0 1↓3 0⌈100+3 1ρ12 0 0|3↑3↓□TS), ' :: ' ), 'AP'[1+12≤□TS[4]], 'M'
```

*Reshaping non-empty lower-rank array X into a matrix*

```
392 (1[-2↑ρX)ρX
402 (-2↑1 1,ρX)ρX
```

*Reshaping vector X into a one-column matrix*

```
203 X+.+,0
534 (Φ1,ρX)ρX
594 ((ρX),1)ρX
```

*Selection depending on index origin*

```
604 X[2×□IO]
609 X[1]
```

*Sorting rows of matrix X into ascending order*

```
9 (ρX)ρ(,X)[A[Δ(,Φ(ΦρX)ρ11↑ρX)[A+Δ,X]]]
8 (ρX)ρ(,X)[□IO+A[Δ[A÷-1↑ρX]] Δ A+(Δ,X)-□IO
```

*Spacing out text*

```
580 ,X,[1.1]' '
490 ((2×ρX)ρ1 0)\X
```

*Temporary ravel of X for indexing with G*

```
585 X←ApX Δ X[G]←Y Δ X←,X Δ A←pX
584 X←(pX)pA Δ A[G]←Y Δ A←,X
```

*Test for symmetricity of matrix X*

```
86  ±±'1', '↑↑' [□IO+∧/(pX)=ΦpX], '' '0~0εX=ΦX''
520 ~0εX=ΦX
```

*Test if all elements of vector X are equal*

```
358 ∧/X=X[1]
343 ∧/X=1ΦX
340 0=(pX)↑+/X
159 v/∧/0 1.=X
324 ∧/X=1↑X
315 (∧/X)v~v/X
311 (↑/X)=↑/X
317 ∧/X÷v/X
352 ≠/0 1εX
316 (∧/X)=v/X
347 ≠/0 1εX
215 X∧.=∧/X
214 X∧.=v/X
341 ∧/X/1ΦX
354 ∧/□IO=X∧X
349 ~∧/Xε~X
```

*Test if arrays of equal shape are identical*

```
357 ∧/,X=Y
544 ~0εX=Y
```

*Test if numeric*

```
400 0ε1↑0pX
486 0ε0\0pX
```

*Test if X is a permutation vector*

```
20 X[ΔX]∧.=1pX
158 ∧/1=+/X.=1pX
346 ∧/(1pX)εX
```

*Value of polynomial with coefficients Y at point X*

```
227 (X*-1+1pY)+.xΦY
83 X1Y
69 (X+.+,0)1Y
```

**Value of Taylor series with coefficients Y at point X**

```
137 +/Y*(X*A)+!A*-1+!pY
281 +/Y*x\1,X+!-1+pY
```

**Vectors as matrices in catenation**

```
273 X,[!IO-(+!2p^/2>(ppX),ppY)/.5 0]Y
274 X,[!IO+(+!2p^/2>(ppX),ppY)/.5 1]Y
```

**X\*X identity matrix**

```
197 (1X)0.=1X
582 (X,X)p1,Xp0
```

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Test if	all elements of vector X are equal	349
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	Number of columns in matrix X	445	
	Number of columns in matrix X	600	
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Ascending cardinal			
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Ascending cardinal			
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Sum of			
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Leading zeroes for positive			
Test if			
Test if			
Transformation of alphanumeric string into			
Test if			
First part of			
Last part of			
Decoding			
Changing			
Converting characters into			
Giving a			
Test if numeric and converting into			
Converting expression X to			
Output of assigned			
Empty			
Reshaping			
Formatting a			
Choosing Y			
Choosing Y			
Number of permutations of X			
Number of combinations of X			
Index of last			
Index of first			
Index of first			
First			
First			
Indices of all			
Number of			

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	Occurrences of string X in string Y	147
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Test if each element of X	occurs only once	353
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Changing an index	origin dependent argument to act as ⌈IO=1	626	
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Changing an index	origin dependent result to be as ⌈IO=1	568	
Changing an index	origin dependent result to be as ⌈IO=0	625	
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	Output of assigned value	630	
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Inverting a	permutation	553
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	Replicate Y[i] X[i] times (for all i)	251
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Number of	rows in matrix X	446
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Boolean vector of length Y with	zeroes after i:th subvector	265
Matrix with X[i] leading	zeroes for positive numbers X in fields of width Y	106
Matrix with X[i] trailing	zeroes in locations X	539
Replacing elements of X not fulfilling Y by blanks /	zeroes on row i	168
Converting	zeroes on row i	165
Vector of length Y with X ones on the left, the rest	zeroes	483
Selecting elements satisfying condition Y,	zeroes to Y	574
	zeroes	407
	Zeroing a vector (without change of size)	608
	Zeroing all boolean values	566
	Zeroing elements of Y depending on their values	545
	zeroing others	622



